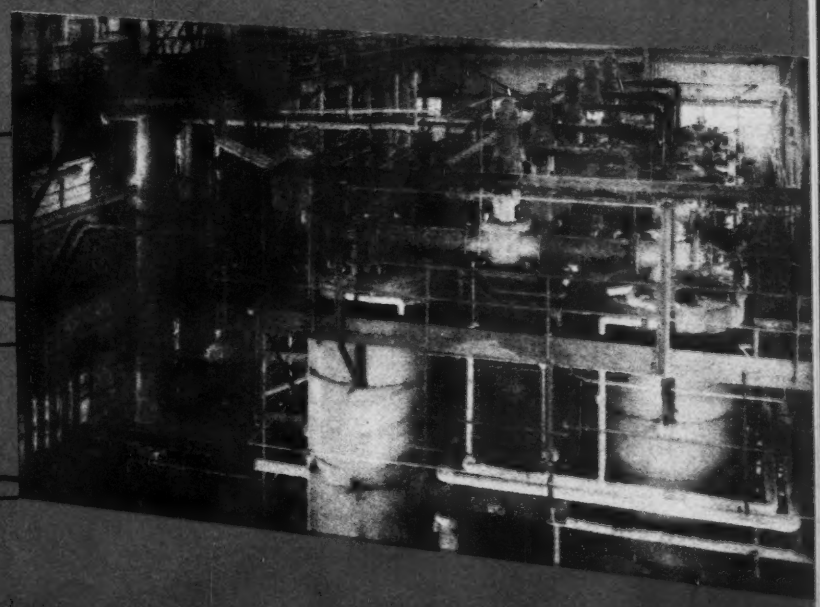
High Vacuum Operation
Theory Vacuum technology

February • 1947

THE TECH ENGINEERING NEWS



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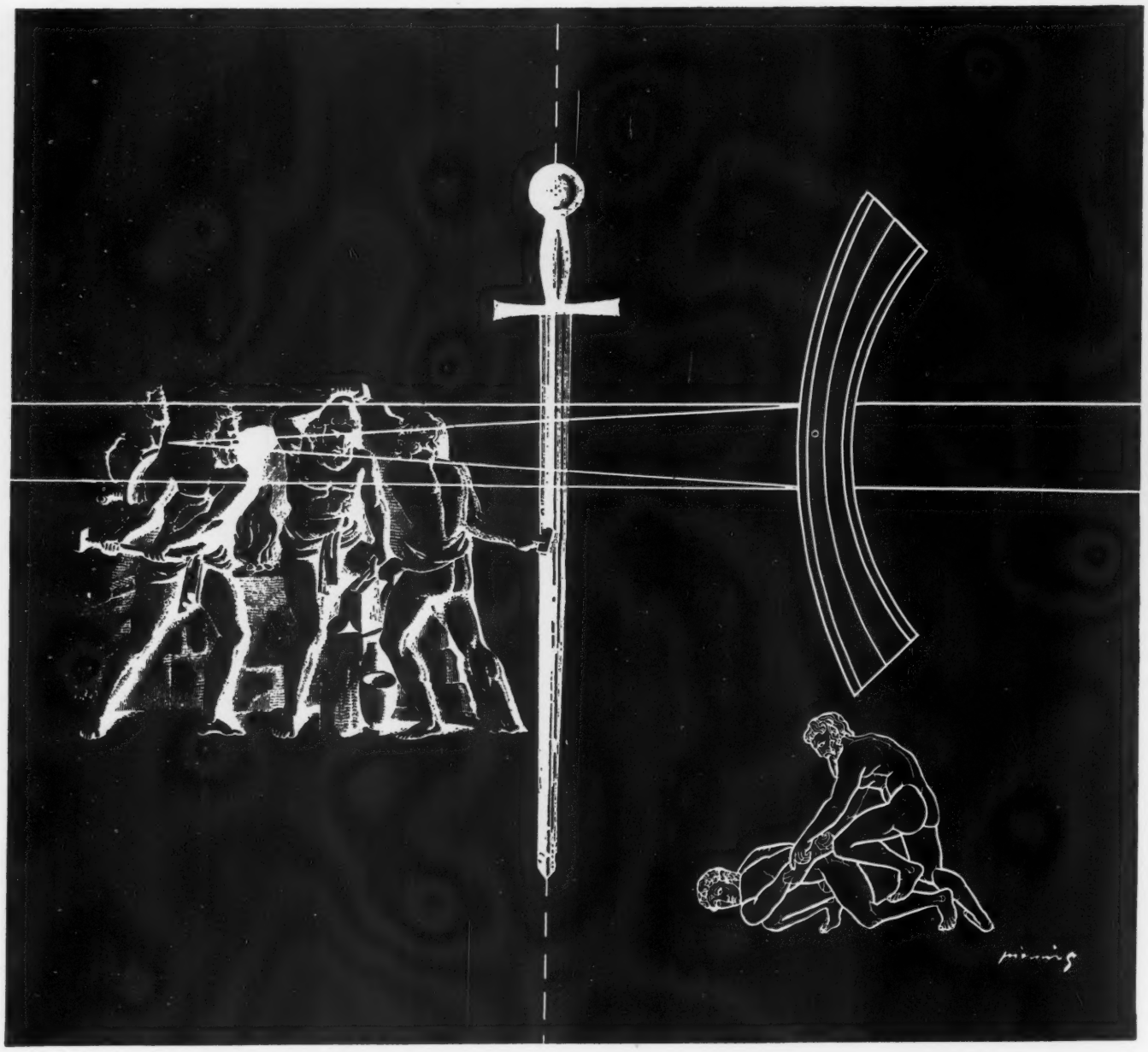
ONE CAME BACK

One of the legends surrounding the making of Damascus sword blades is that the smiths developed a delayed quench consisting of thrusting the heated blade into the body of a slave. This gave the required properties, but it was prodigal of manpower, and inconvenient besides. The smith usually had to leave town to do his heat treating in quiet.

Today, metallurgists can obtain properties they need in steel by simpler, less improvident means. A little molybdenum is one way of doing this. It is a proved means of obtaining the hardenability that assures good performance in service. Practical working data on molybdenum steels are available from Climax upon request.



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MOLY

"Without laboratories men of science are soldiers without arms"—LOUIS PASTEUR

Why some things get better all the time

THE SPAN OF LIFE is increasing. Within the last half century the average length of life of a new born infant has increased over 30%. And many more people over 40 can now expect to live well into their seventies.

Among the reasons for this progress, along with notable advancements made by the medical profession, are the improvements in medicinals and medical equipment that help guard life.

Synthetic organic chemicals now are used in the production of a host of pharmaceuticals, including penicillin and the sulfa drugs, which have accomplished wonders in the fight against germs. They also are used in repellents to defeat disease-carrying insects. Out of research with gases has come oxygen therapy, an aid to recovery in numerous illnesses. Research with metals and alloys has produced the gleaming, easy-to-clean stainless steel used in modern hospital and medical equipment.

In safeguarding life—just as in transportation and communications—much of man's progress is traceable to *better materials.*

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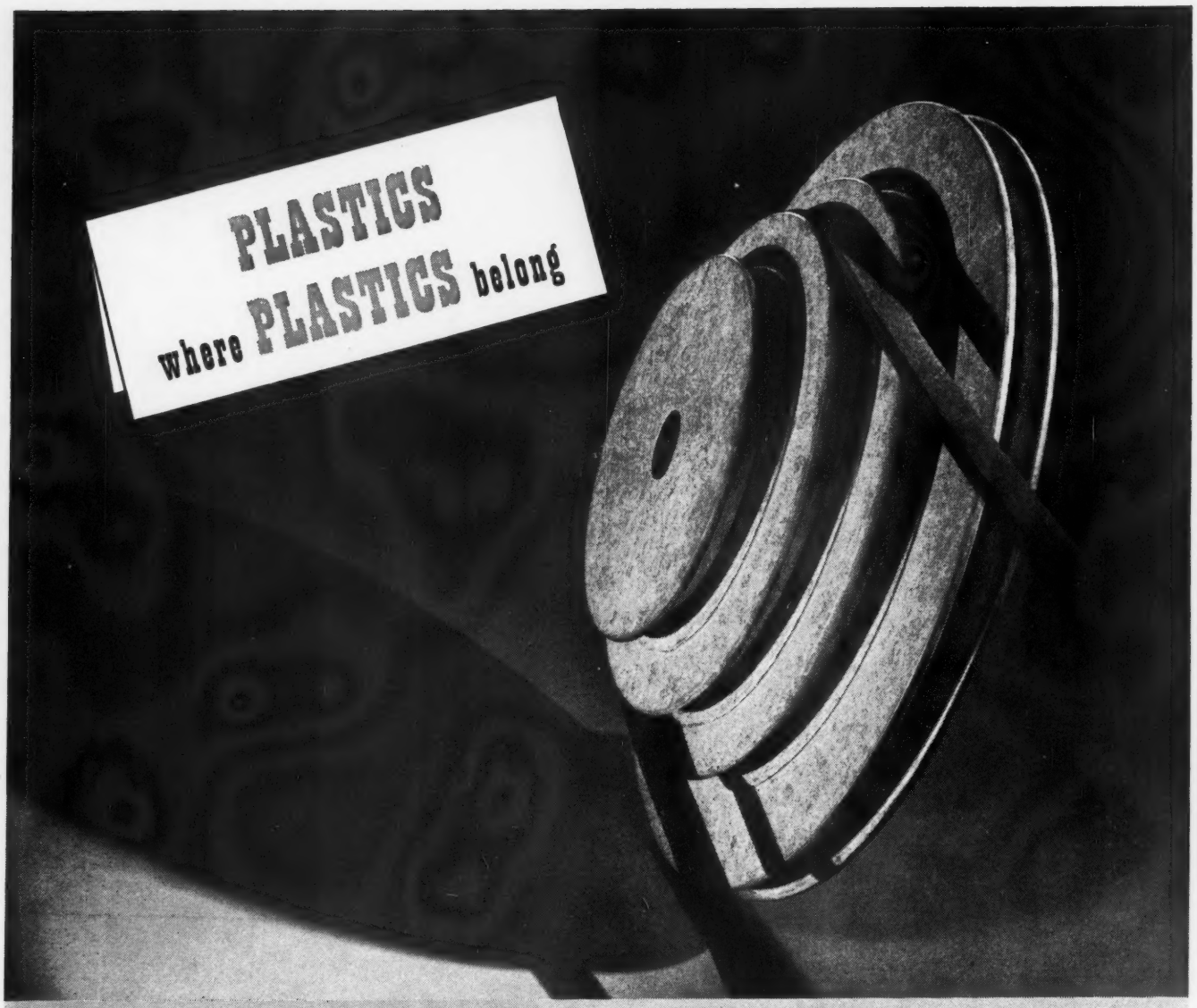

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FAST STARTING and stopping are top requirements of high speed vee-belt pulleys. Other things being equal, the lighter the weight the faster the pulley will stop and start.

Synthane weighs less than any suitable metal — half as much as aluminum — and it is strong, uniform and easily machinable.

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Briefing the News . . .

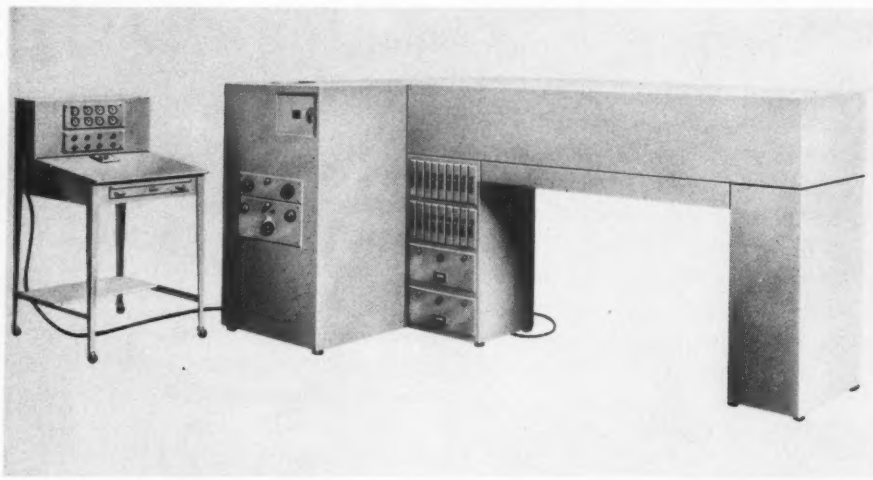
A Camera that Makes Positive Photographs . . .

MR. EDWARD H. LANDER, president of Polaroid Corp., has invented a camera that takes a positive photograph and develops it within fifty seconds, so that the picture can be seen as soon as it is taken.

This remarkable invention uses a conventional silver bromide coated film on which the photograph is taken. The camera also holds a roll of positive paper, to which tiny vials of developing solutions are attached every few inches. When the picture has been taken, the negative and positive are pulled out together through a slit near the bottom of the camera. As they are withdrawn, one of the tiny vials of chemicals breaks and floods the two surfaces in contact with developing and fixing solution.

The silver bromide on the part of the negative that has been exposed to light is quickly reduced to a dark deposit of silver. The remaining bromide is soluble in the fixing solution, and is partially absorbed by the positive. Within a minute it, too, is reduced to silver, and forms a dark image on the positive opposite the light areas on the negative. Then the positive and negative can be pulled apart, and a positive photograph obtained.

The invention will be of inestimable aid to amateur and perhaps even professional photographers who want to see how a picture has turned out as soon as it has been taken. The invention is expected to go into production shortly.



The direct reading spectrometer which analyzes metals in two minutes

A Direct Reading Spectrometer . .

From Baird Associates comes news of a new spectrographic instrument which indicates directly the *percentage* composition of an element in an alloy or mixture. It utilizes a complete diffraction grating spectrometer and two photocells. On one of the photocells is focused a spectral line from a reference material in the mixture, usually its principal constituent, such as iron in a steel alloy. On the other is focused a line of another element. An electronic circuit compares the two line intensities logarithmically, and indicates on a meter the relative concentrations of the two constituents of the mixture.

The new analysis method is said to give an accurate analysis within two minutes.

Graphitic Corrosion . . .

A peculiar type of disease sometimes attacks cast iron in which the iron dissolves completely, leaving behind the carbon which was originally dispersed throughout the iron. Unlike in ordinary rusting, there is no formation of red iron oxides and hydroxides, and the outward appearance of the casting seems almost unchanged. The surface, consisting almost entirely of graphite, is extremely soft, however, and can be cut away with a knife.

The *Nickel Cast Iron News* (Spring, 1947) says that the city of Newark, New Jersey, recently has had several occasions on which cast iron valves on the water mains had failed. When the valves on the mains were taken to be repaired, they seemed to be covered only with a slight coasting of rust. On closer examination, however, it was found that their surface had entirely deteriorated to a considerable distance, and could be peeled off with a knife.

This form of corrosion, known as graphitic corrosion, is principally found in water pipes, where the iron salts and oxides formed by corrosion are carried away by the water.

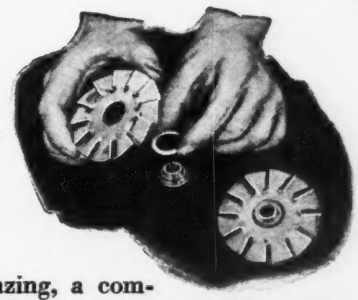
Relief for Frostbite Victims . . .

A new drug, *heparin*, is coming into use to prevent the painful and often serious after-effects of frostbite. The new chemical prevents the clotting of the blood in damaged tissue, which is now supposed to be the principal cause of the pain and the destruction of tissues that accompanies frostbite.

Drs. Kurt Lang and L. Boyd of the New York Medical College performed several experiments on rabbits to prove that the damaging effect of frostbite was caused by blood clotting. They injected the rabbits with fluorescien, and observed minute capillaries near the skin of the rabbits under a microscope after frostbite had been caused by exposing patches of the rabbits' skin to dry ice. Under ultraviolet light, the fluorescien became phosphorescent, and the scientists could see that the blood plasma was leaking through the damaged capillary walls, leaving behind masses of red blood cells, around which the blood clotted.

Administration of heparin, the new biological chemical which has been so strikingly effective in preventing pulmonary embolism, prevented the blood from clotting, and the rabbits so treated quickly returned to normal.

ALUMINUM BRAZING—
another victory of Alcoa Research



Problem: How to join a stamped aluminum fan blade to a machined aluminum bushing to make a fan for portable electric tools.
Answer: Assemble the two parts with a special aluminum alloy ring in between and put them in a furnace. The ring melts and joins the parts together solidly.

This is an example of furnace brazing, a comparatively new way of joining aluminum to aluminum. It is another of the ways in which Alcoa Research has made aluminum more useful and more economical to fabricate.

Alcoa metallurgists first had to find an aluminum alloy that would melt at lower temperature than the aluminum parts it was to join. Then, in order to get a direct metal-to-metal bond, they had to find a way to disperse the thin film of oxide that covers aluminum.

Finding a low-melting alloy was relatively simple. But it took years of persistent research to produce a mixture of chemicals that melted with this brazing metal and removed the oxide film. The discovery of this flux made brazing practicable.

Such discoveries are not unusual when Imagination teams up with Engineering. At Alcoa we call it *Imagineering.*

Remember that—*aluminum can be brazed.* Someday it may be the answer to your *own* design or fabricating problems.

Remember, too, that the best place to turn for answers to any problem about aluminum is the place where the most research has been done on this strong, light, versatile metal . . . the place where there is the most knowledge about its use. Turn to Alcoa.

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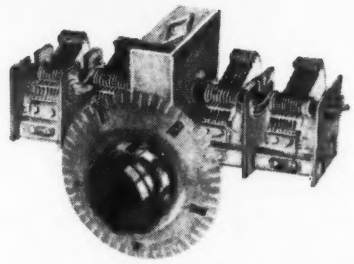

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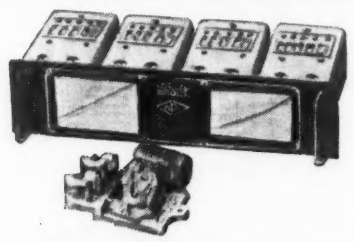
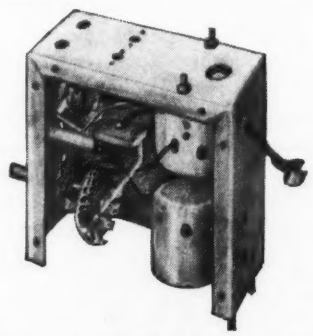


Ganged Plug-in Coils. Two stages of preselection for image suppression, weak signal response and high signal-to-noise ratio.



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The TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Volume XXVIII, No. 5

FEBRUARY, 1947

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Design and drawing by Katherine Rogers

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A portion of the moon near the last quarter

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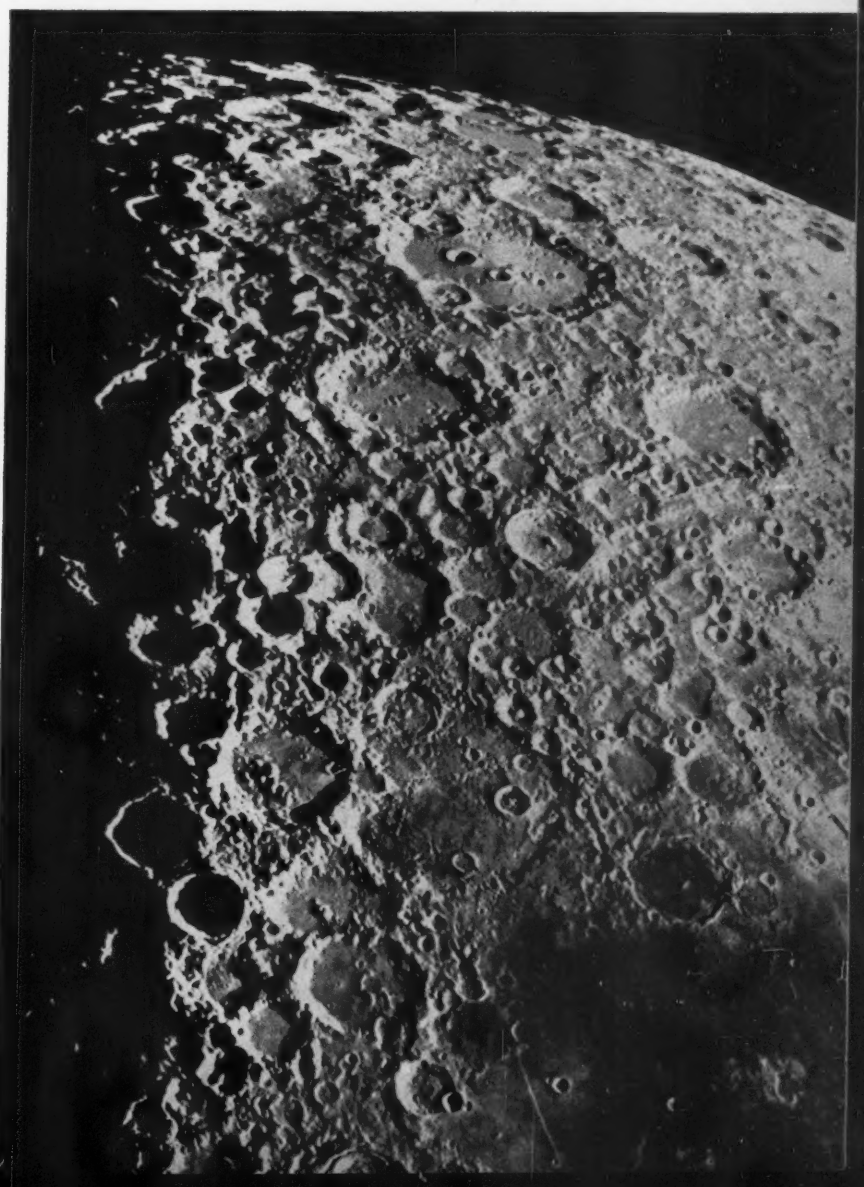


A "Christmas Tree," the ultimate goal to the oil man . . . he has complete control of the well's production. Robert Y. Richie

Chemicals from Petroleum

By HAROLD CONROY, '48

THE remarkable development of techniques of component separation of petroleum appearing in the past few years, coupled with the use of several new reactions hitherto employed only on a laboratory scale, has permitted the commercial production of many compounds from petroleum which were previously obtained elsewhere, or were unobtainable. For example, recent figures released by the United States Tariff Commission show that for the year 1944 out of the fifteen and one-half billion pounds of synthetic organic chemicals manufactured in this country, three billion were produced from petroleum raw materials, effectively demonstrating the growing importance of petroleum supplies for chemical industry. No longer can it be said that chemistry depends entirely upon coal tar and the naturally occurring raw materials for its building blocks.

Glycerol

Perhaps one of the most striking of these new processes is the produciton of synthetic glycerol from propylene, a constituent of refinery cracked gases. The process was developed in the Shell Laboratories at Emeryville, California, and, after considerable research was carried out on a pilot plant scale, a full-scale plant for the production of glycerol and its intermediates, allyl chloride and allyl alcohol was placed in operation at Houston, Texas.

The process is essentially as follows: Allyl chloride is manufactured by the non-catalytic chlorination of propylene in the vapor phase at about 500° C. in adiabatic reactors. The principal reaction involved is the substitution of an atom of chlorine for an atom of hydrogen in the propylene molecule.

$$Cl_2+CH_2:CH\cdot CH_3\rightarrow CH_2:CH\cdot CH_2Cl+HCl$$

The chief secondary reaction encountered is the further chlorination of allyl chloride to 1,3 dichloropropene.

$$CH_2:CH\cdot CH_2Cl+Cl_2\rightarrow Cl\cdot CH:CH\cdot CH_2Cl+HCl$$

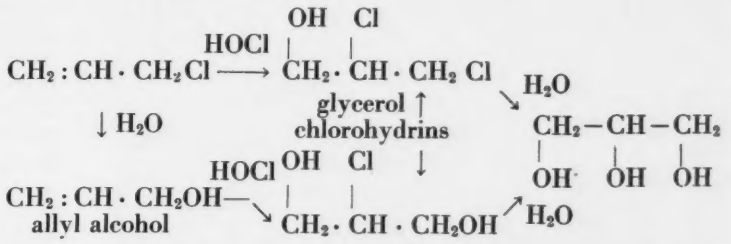
Another important side reaction which occurs is the additive chlorination of propylene to form 1,2 dichloropropane.

$$CH_2:CH\cdot CH_3+Cl_2\rightarrow Cl\cdot CH_2\cdot CHCl\cdot CH_3$$

This reaction is favored by low temperatures, and at reaction temperatures of 200° C. and lower takes place to the virtual exclusion of substitution reactions. Nevertheless, dichloropropane is always present in the product to an appreciable extent even with reaction temperatures as high as 600° C.

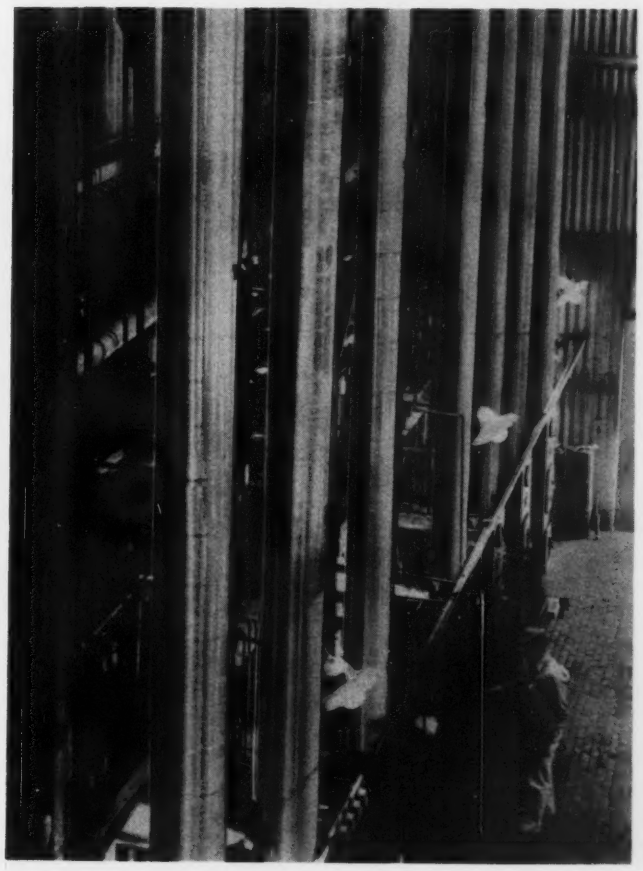
The gaseous reaction mixture is passed through a cooler which condenses out the allyl chloride, leaving a mixture of unchanged propylene and HCl gas. The latter is absorbed in water to produce hydrochloric acid of commercial strength, while the propylene is compressed and recirculated, the whole being a continuous process. The allyl chloride is purified by fractionation.

Glycerol may be prepared from either allyl chloride or allyl alcohol by chlorohydrination, that is, addition of hypochlorous acid, HOCl, to the double bond, and subsequent hydrolysis of the resulting glycerol di- or mono-chlorohydrins, the over-all yield in either case being 90 per cent. The allyl alcohol of course, may be made in good yield by the hydrolysis of the allyl chloride.



The synthetic glycerol process is important since the world demand for glycerol had long threatened to exceed the supply, since previously that compound had to be regarded only as a by-product of the soap industry. Its uses are well known: dynamite manufacture, in paper making, in the manufacture of rayon, cellophane, and in certain inks. Also, the intermediates in this synthetic glycerol production, allyl alcohol and chloride, have found new uses of their own. Allyl alcohol is used in the manufacture of pharmaceuticals,

Precision distillation columns for the separation and recovery of hydrocarbons in pure form. These fractionators make it possible to recover some components with a purity of over 99x%. *Phillips Petroleum Co.*



American Institute of Chemical Engineering

Dehydrator and batch still for methylpentadiene and dimethylsulfolane.

and its esters are employed in perfumes and flavorings. Diallyl phthalate deserves special mention, since its polymers represent an unusual combination of superior appearance, strength, electrical resistance, hardness, resistance to chemical attack, and laminating properties.

Cyclohexane

Another compound now being prepared from petroleum is cyclohexane. This material has long been made through the hydrogenation of benzene derived from coal tar, a relatively expensive method. The development of cyclohexane from petroleum will do much to relieve an anticipated benzene shortage, occasioned by increased demands of phenol and styrene, and will permit the diversion of benzene to products long ago cut off from a supply.

Practically speaking, cyclohexane can be recovered from petroleum by either of two routes: (1) Fractionation of petroleum and (2) the isomerization of methylcyclopentane to cyclohexane. If fractionation by the usual methods is employed for the recovery, the problem is especially difficult. In both natural and straight-run gasolines, there are a number of other compounds with boiling points very close to that of cyclohexane (80.4°), and some of these interfere with the separation. One of the most troublesome compounds to remove is 2,4 dimethylpentane, whose boiling point is practically identical with that of cyclohexane. The problem is further complicated if cracked stock, with its resulting olefins and aromatic compounds are employed as feeds for cyclohexane preparations.

However, the Phillips Petroleum Company has recently found it possible to recover a cyclohexane concentrate from natural gasoline by fractionation methods. Operation of distilling equipment of very high efficiency (possessing at least one hundred actual plates or more) is involved, as is the employment of very high reflux ratios. Because of the inherent difficulty of this separation, recovery of cyclohexane from petroleum represents a milestone of progress in fractionation techniques. A product containing as much as 87 per cent cyclohexane may be prepared.

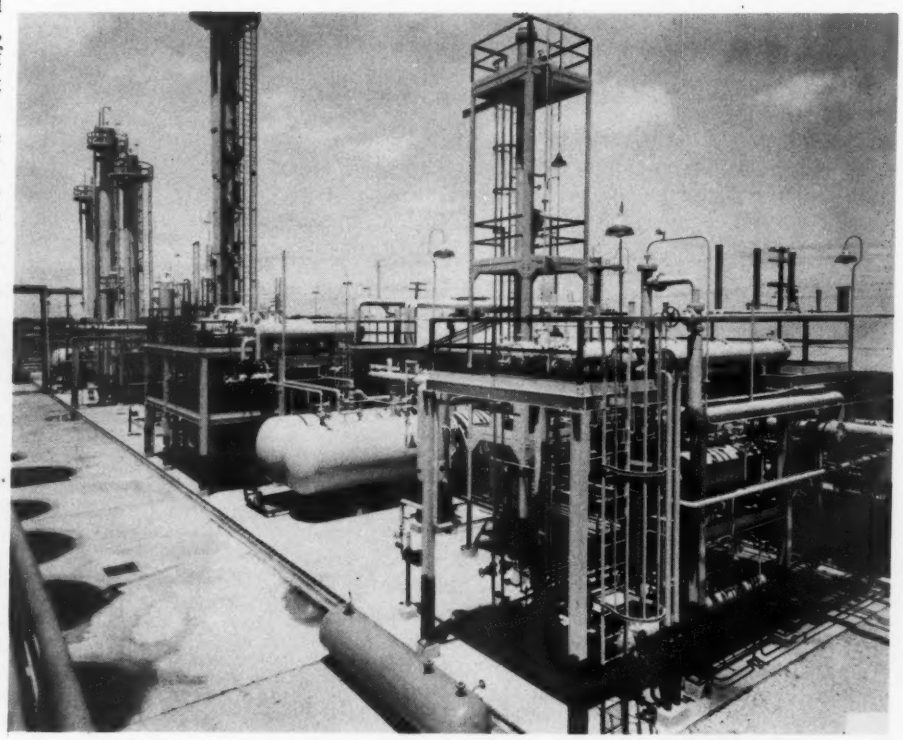
The isomerization process depends on the fact that it is possible to prepare a *n*-hexane, methylcyclopentane concentrate containing appreciable quantities of the latter and substantially free of any other hydrocarbon compounds. Subjection of this mixture to mild isomerization conditions with Friedel-Crafts type catalysts, *e.g.*, anhydrous aluminum chloride, will result in the selective isomerization of the methylcyclopentane to cyclohexane with very little of the *n*-hexane content being affected. The original mixture contains no material boiling above 74° C., while after isomerization the product would contain cyclohexane boiling at 80.4°. Separation of the latter is thus made simpler, and a product of fairly high purity can be prepared.

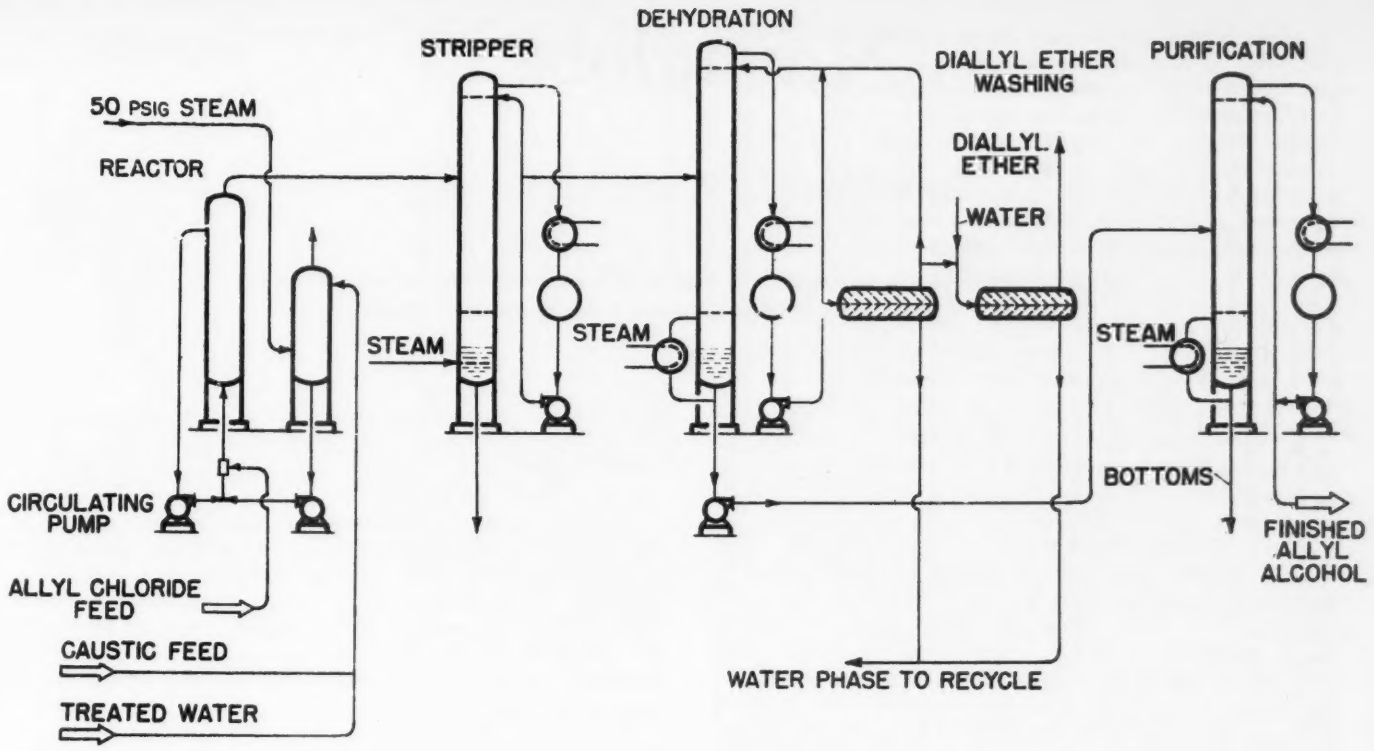
It is obvious that the potential production of cyclohexane from petroleum in this country is enormous, although it is doubtful if more than a mere fraction of the total will ever be recovered. One of the most interesting uses of cyclohexane is in the manufacture of adipic acid, for nylon, by oxidative ring opening. Another important use of cyclohexane is as a solvent, particularly in the manufacture of cements. Its comparative non-toxicity and good solvent power make it particularly attractive for this use.

Ortho-xylene

A relatively new aromatic hydrocarbon is ortho-xylene, currently being employed in a new oxidation

Cleanliness and efficiency are depicted in this view of a large-scale production unit for allyl chloride, an intermediate in the preparation of glycerol from natural gas and petroleum. American Institute of Chemical Engineering





Flow diagram for the commercial production of allyl chloride. *American Institute of Chemical Engineering*

process for phthalic anhydride, an important intermediate for the plastic and dyestuff industries. Separation of the ortho-xylene by distillation or precipitation techniques from its meta- and para- isomers, with which it occurs in cracked petroleum fractions, is especially difficult owing to the proximity of freezing and boiling points of these and related compounds. The problem of purification is further complicated by the presence of small amounts of paraffinic hydrocarbons, notably some of the iso-nonanes and trimethylcyclohexanes, which boil in the same range as ortho-xylene.

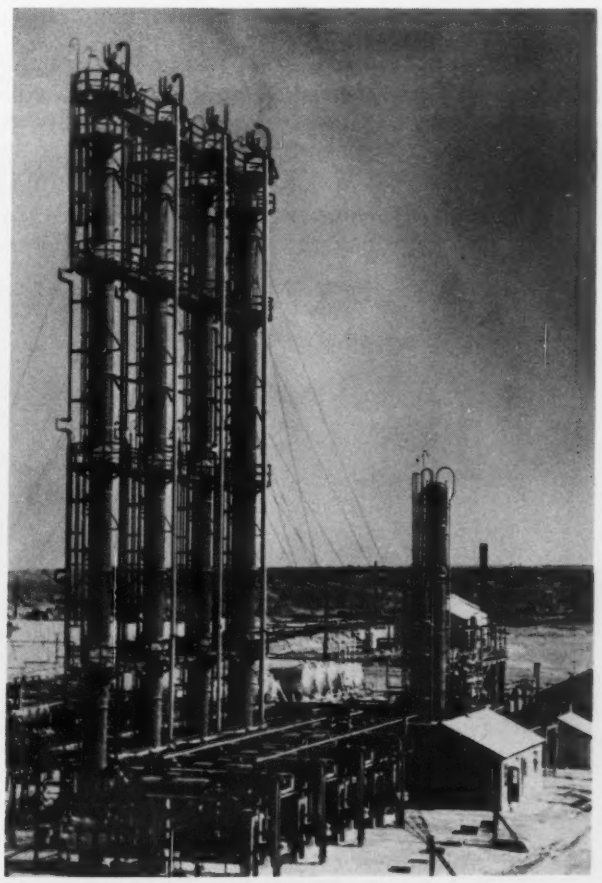
Recovery of high purity ortho-xylene from petroleum has been made possible by two separate developments: (1) the perfection of petroleum conversion techniques (*e.g.* the Hydroforming process) which give high yields of aromatic compounds, and (2) a refinement in conventional distillation practices.

Hydroforming is a high-temperature, catalytic process, whose action takes place in the presence of hydrogen; yet hydroforming is not hydrogenation; on the contrary it is dehydrogenation, and part of the hydrogen produced is recirculated merely to control the rate and extent of dehydrogenation. The most important property of the catalyst is that it causes ring formation in molecules which have just undergone partial dehydrogenation. The final product thus contains a high percentage of aromatic, and a small quantity of aliphatic, compared with the feed. From such stocks suitable concentrates can be prepared which serve as the feed material for the final purification step where full advantage is taken of the fact that ortho-xylene is the highest boiling of the three isomers. As with cyclohexane, distilling columns operating under very high reflux ratios are necessary. By suitable process control, a product with purity in excess of 90 per cent is possible.

Mixed xylenes from coal tar sources have been

(*Continued on page 210*)

Superfractionation plant for producing special hydrocarbons for experimental use. *Phillips Petroleum Co.*



Navaglobe

By RICHARD W. SPENCER, '49

All pictures and diagrams courtesy of Federal Telecommunications Laboratories of the International Telephone and Telegraph Corporation

AS one result of the tremendous use of airplanes made during the second World War, much thought and research have gone into the development of various navigational and locational systems. The need of such systems is clearly demonstrated by the increase in airplane casualties with the increase in air traffic. One need is to have a method of landing at airports quickly and automatically. This has been described in a previous issue. Another very important need is for a long-range navigational guide — pilots can find out where they are in relation to fixed points without regard for the weather or visibility outside — and accidents which occur because the plane gets five degrees off its course and flies thousands of miles out of its way to a gloomy and violent end will be cut down in number. This system, as developed by the Federal Telecommunication Laboratories Research at Nutley, New Jersey, is called Navaglobe, navigation around the globe.

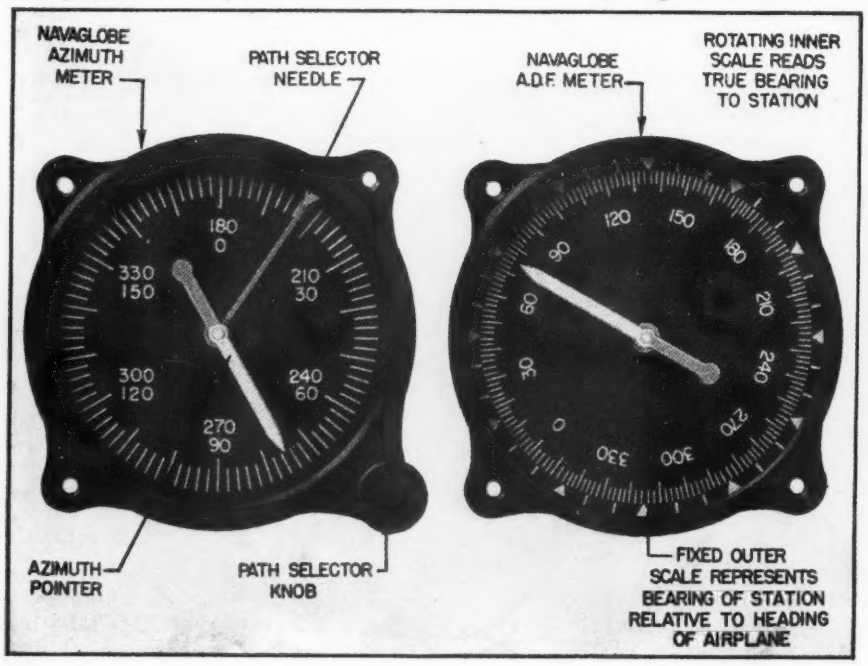
The basic problems of the system were formulated by consultation with various Army-Navy agencies and airlines as follows:

1. Guiding aircraft over oceans, uninhabited jungle or arctic regions.

2. The navigation of aircraft along already established airways which can be provided with radio ranges or other similar facilities.

There have been proposed many different systems for long-range navigational control. The essential requirements are: one hundred percent reliability of propagation of the signals over the whole area to be covered at every hour of the day and night at every season of the year; a minimum area of coverage sufficiently large so that every travelled portion of the earth's surface may be covered by at least two stations (separate from each other) without requiring the construction of man-made islands as bases for these islands (such a situation might occur in the southeast Pacific); and finally, some provision for checking the relative accuracy of the indications given by these stations. If these conditions can be met, the advantages of having an airplane which can ascertain fairly closely its position are so obvious that they would offset the sacrifice in convenience, accuracy, weight, cost, or any other factor. An airplane pilot could determine his position anywhere, anytime, and double check the answer. Together with these basic minimum conditions are secondary ones which add greatly to the convenience and ease of operation such as simplicity of operation and convenience of reading, single-site stations instead of double-site, reduction of the drag on airborne antennas, reduction of airborne weight, reduction of the cost of ground and air equipment, capability of being modified eventually to give fractional-degree accuracy for special purposes. It should be realized, though, that in long-distance navigation, a high order of accuracy is not very important since it does not matter exactly how far an airplane is from its destination, whether 10, 25, or 100 miles, as long as it approaches the destination. Most operational people dismiss the question of high accuracy with the statement that "over the ocean nobody cares where he is within 20 or 30 miles." Only for very special or military purposes, then, could high accuracy be useful or worthwhile.

Comprehensive informative dials are standard Navaglobe indicators.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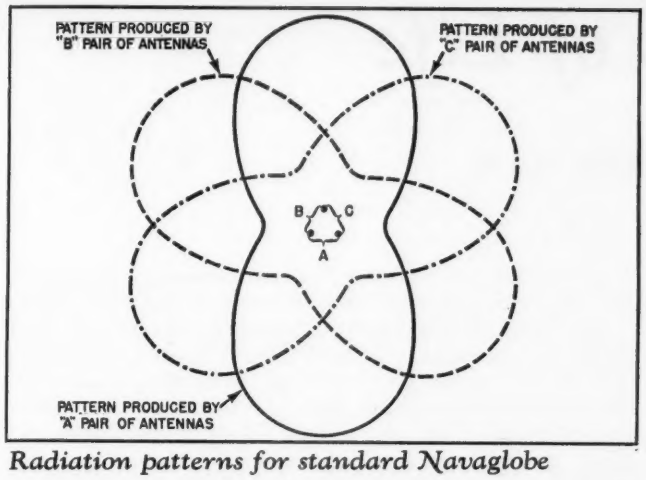
210 30
300 120
240 60
270 90
120 150 180 210 240 270 300 330 0 30 60 90
AZIMUTH POINTER
PATH SELECTOR KNOB
FIXED OUTER SCALE REPRESENTS BEARING OF STATION RELATIVE TO HEADING OF AIRPLANE

To determine the practicability of the world-wide coverage, reference was made to the Hydrographic Office of the Geodetic Survey. It then appeared that the reliable transmission radius would have to be at least 1500 miles in order to provide the duplicate coverage of important ocean regions as specified above. Duplicate coverage allows navigators to take duplicate fixes, establishing cross lines which determine position fairly accurately. The global view pictured below shows a possible pattern of stations which would achieve the result of duplicate coverage all over the globe, except in the south polar region. It will be noted that there are no stations located on continental areas as these present no difficulties of any sort except perhaps mountain block of transmission. A total of around 60 stations would suffice for covering all the ocean areas; with the con-



Radiation patterns for standard Navaglobe

tinental areas also included in the count, complete coverage of the globe (except for the desolate and definitely untravelled south polar cap) would require 75 stations.

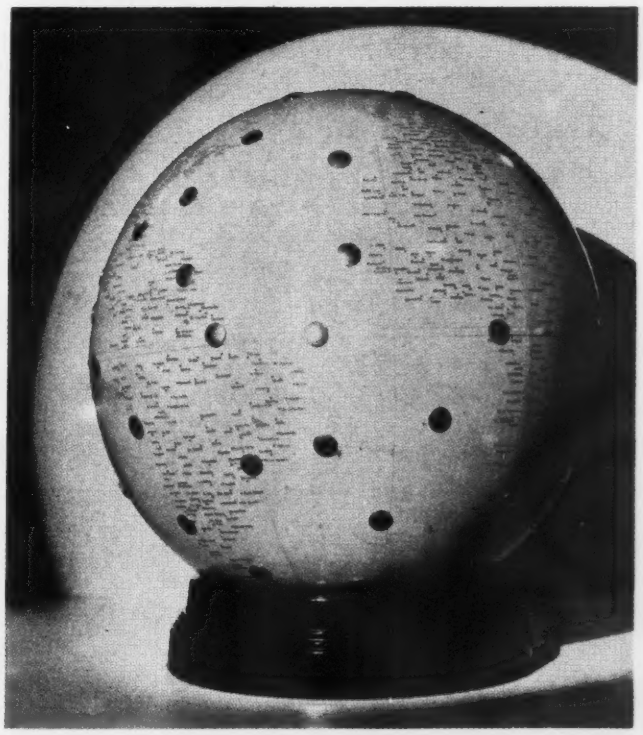
An intensive study of the propagation characteristics of various radio frequencies was undertaken to ascertain with assurance which frequencies could be relied on to propagate to a distance of 1500 miles over sea water 100 per cent of the time. Needless to say, it was soon found that no radio propagation can be 100 per cent reliable, but after a careful review of the literature, it was possible to achieve reliability in excess of 99 percent. This is practical only through the use of low frequencies in the vicinity of 70 kilocycles per second and with extremely narrow bandwidths of the order of 10 to 20 cycles per second.

For a given radiated power, it can be shown that frequencies between 15 and 70 kilocycles are the best from the standpoint of reliable reception, taking into account the weakest signal propagation and the highest atmospheric noise level, but disregarding antenna cost and efficiency. However, if simpler and cheaper antennas are used, and the power input to the antenna tripled, then frequencies as high as 175 kilocycles can be used with safety. More power is needed in the tropics because of certain interferences; in fact, much of earth's static is said to originate in the tropics and subtropics. It is estimated that, except for a regular brief interruption lasting about 15 minutes at an accurately predictable time in the evening, the signal-to-noise ratio would be sufficient for reliable operation approximately 99.9 per cent of the time.

The Navaglobe system is a low-frequency continuous-wave omnidirectional range which is received on the airplane by a very narrow band receiver equipped with a special azimuth indicator as illustrated in the picture of the dials, on the left. This narrow band range receiver makes use of a loop antenna, shielded to minimize the effects of precipitation static and cross-field corona static. Since this loop antenna can be made directive, this provides an automatic direction-finder indication in the airplane, as shown in the right-hand dial. Both functions are completely automatic and go into operation when ground equipment is switched on. The azimuth meter as shown represents a reading of 255 degrees, or the azimuth angle of the airplane as seen from the ground station broadcasting within the range of the plane. The A.D.F. meter is the true bearing from the aircraft to the ground station or the reciprocal of the azimuth angle or 75 degrees. (In navigation, A and B are reciprocal angles where $A \pm x\ 180° = B$). This reciprocal relationship holds up to the point where the convergence of the meridians matters. It may be seen that the right hand dial in the figure reads 75 degrees. Although it may seem valueless to have two reciprocal readings because the errors might repeat and add up, the two readings are quite independent and constitute a check on one another. A complete failure (breakdown of the transmitter or receiver) will disable both meters, but this type of trouble will be detectable at once. The most serious danger which must be guarded against in any navigation system is not so much the danger of an obvious failure, but the danger of incorrect operation which is not apparent. It is axiomatic that no system upon which human life depends should be designed without a method of double checking the answers given. The possible errors in the A.D.F. of Navaglobe are independent of the azimuthal readings. The principal sources of error in A.D.F. are polarization errors, errors in alignment or balancing of the loop, and errors in the mechanism used for converting the loop signals into metered indications. The main sources of azimuth-meter error are waves reflected from large objects such as mountains in the vicinity of the transmitter, errors in the relative phasing of the transmitter antennas (resulting from the detuning of the antennas by sleet or sag, or from misadjustment of the phase-determining circuits in the transmitter or transmission line equipment), and finally, errors in the indication equipment used for producing the pointer deflection of the azimuth meter. It can be shown that none of these errors is likely to affect both the azimuth and automatic-direction finding meters. Therefore, they can be checked against each other and a balancing of errors seems rather improbable.

Navaglobe would provide a global air net for the safe operation of airliners and commercial planes over the most dangerous places, such as the ocean and the North Pole. With the increasing growth of the air industry, in spite of recent spectacular setbacks, techniques like Navaglobe will contribute to the safer and more efficient operation of the airways of the future.

On the globe are located points for stations which would give complete coverage of the Earth's surface, providing a unique navigational aid.



Molecules of Life

By *LESTER FRIEDMAN*

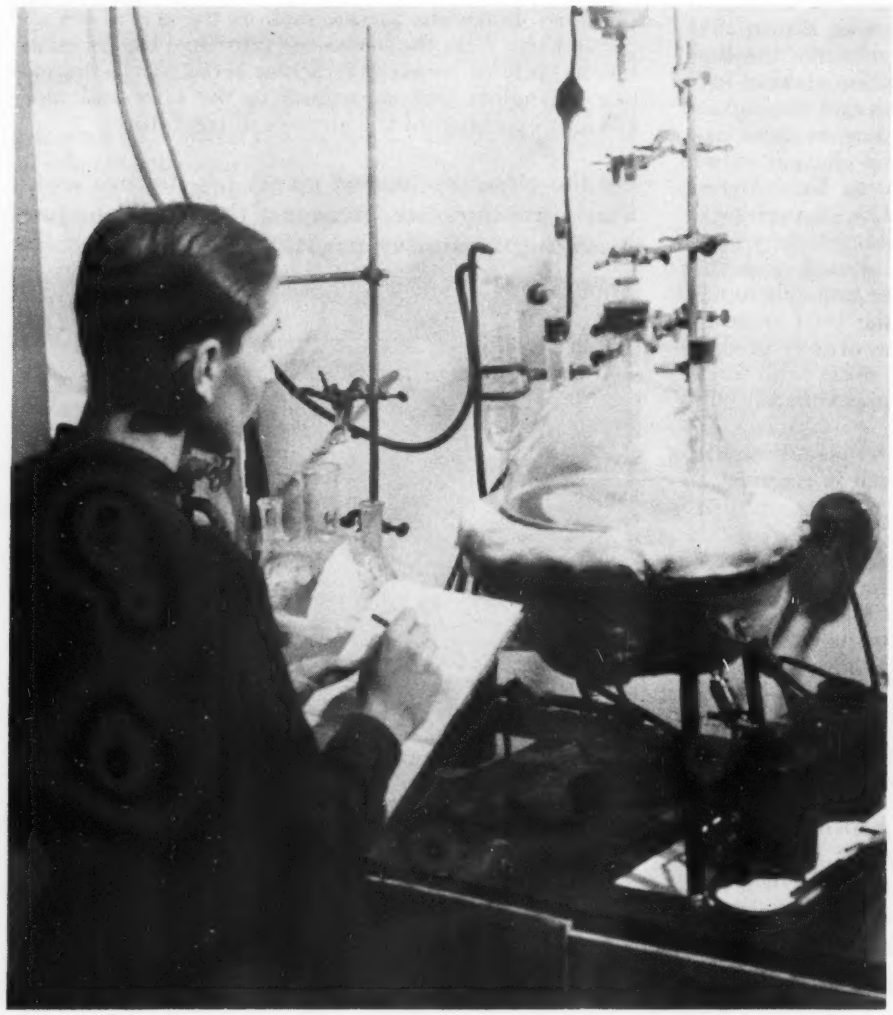
EVER since Methuselah lived nine hundred and sixty-nine years while most of *homo sapiens* was passing back to ashes and dust at threescore and five, man has tried unsuccessfully to ward off the steady approach of senility and extinction. Through the ages he used various symbols and devices to prolong his animate existence. Students of history can easily see the trend from paganism, theism, and today — science. We recall Ponce de Leon's Fountain of Youth as sheer folly, but it is now a practical reality.

Modern science, notably the organic chemists and endocrinologists have found one of the answers, the magi of hormones. Hormones (from the Greek *hormao*, to excite) are secretions of various glands which have a special and specific exciting effect on certain tissue. To date we can ascribe definite functions to the secretions of all but the pineal and thymus glands. In order for one to understand the effects of these materials the chemistry and physiology and some interesting interrelationships will be presented. If by any chance you are under the impression that the hormones are wonder drugs or the new panacea, let me discourage you now, they are only nature's tools recently brought to light.

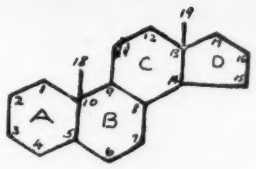
Towards the end of the nineteenth century a French scientist, Berthold, reasoned that if castration robbed one of his vitality (Berthold's physical data is unavailable), would not replacement of what was lost remove this deficiency? He was indeed taking a new approach! With his crude surgery he castrated four roosters and grafted to two of them testes on their stomach wall, using the other two as controls. (He also read *Novum Organum.*) Both France and he were surprised. The capons and confused roosters survived and acted as such. He proved quite definitely that the testes were responsible for masculinity, and that a castrate plus them was no longer a castrate, but a normal individual. (In the above a rooster.) One Frenchman was really impressed, and being no less than a member of the Academie de Science, etc., injected himself with a saline extract of bull testes. At his advanced age of seventy-two, he thought he could use some rejuvenation, and acted as a man of twenty-five. He was active for a few months, but then folded up and died, realizing, however, that that was possible only through the power of suggestion. Because of this folly, medicine and the rest of science avoided hormones till the 1920's, for in the '90's sex was taboo.

A chemist checks one of the many steps necessary in the synthesis of a sex hormone.

Herbert Kosower

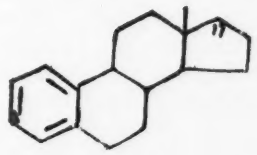


With the hormone (sex) renaissance of the twentieth century science experimented with the effects of castration (male and female), transplantation, restoration of sexuality through the use of glandular extracts (from the testes, ovaries, urine, placenta, corpus luteum) and concentrates. The effects of castration on the male (an act practiced for centuries) is dependent upon the age when castration takes place. Much information was gained by the studies of the Skopecs, a Russian religious sect who practiced castration in the first decade of life. Following early castration the eunuch has an underdeveloped penis, prostate, and seminal vesicles. The beard and other masculine adornments were absent and the change of voice never took place. To sum it up, he will retain all his infantile sexual characteristics and gain none. Castration after puberty produces less marked effects. The effects of castration are most easily observed on birds. Their plumage atrophies and may ultimately disappear. Female castration (ovariectomy) leads to corresponding changes. The gonads either remain infantile or atrophy. Menstruation obviously ceases, and



Etiocholane I

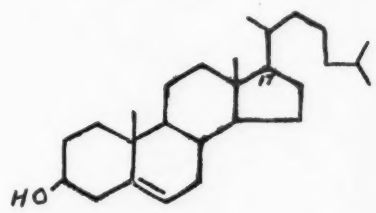
Perhydrocyclopentanophenanthrene



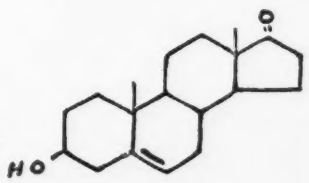
Estrane II

a secondary change is obesity. Generally speaking, gonadal implants and the pure hormones will restore the secondary sexual properties, but they by no means replace the real thing. That we are a product of our hormones is seemingly obvious but, are they not a product of us?

Before continuing I hope that you will not get the impression that we are either completely masculine or feminine. Both the male and female manufacture and secrete their quota of male (androgens) and female (estrogens) hormones. Their endocrine difference for masculinity and feminity differ only on a *quantitative* basis and not qualitatively. "Animals are not selectively and exclusively male and female, but are intermixtures of both potentialities in which usually one set of characters predominates. Without a clear dominance of one set of characters the animal becomes an intersex or hermaphrodite." The late Benchley artfully satirized a similar quotation. Because of this the study of the



Cholesterol V



Dehydroisoandrosterone VII

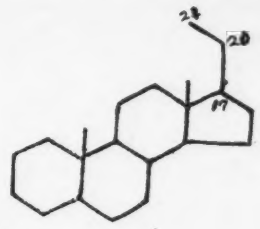
3-(β)Hydroxy-17-keto-Δ⁵-etioallocholene

effects of the sex hormones on the sexes is decidedly difficult. Due to the dual nature of our bodies we must bear in mind also that the gonads are not the sole site for the manufacture of estrogenic and androgenic bodies. An interesting fact is that the average male excretes estrogenic material in an amount equal to that of a "weak" female. Social authorities have cooled sex maniacs (male) with the aid of estrogenic hormones. The results were weak and disillusioned individuals.

Modern endocrinology began about 1912 with experiments by Nussbaum on the frog, and outstanding contributions were made by Allen and Doisy who in 1923 obtained estrogenic concentrates and tested their actions on animals, and by Koch and Gallagher who isolated a male hormone concentrate. This work was then continued by Butenandt and other workers who by 1935 had isolated all of the known hormones in pure crystalline forms. From 1935 to the present an avalanche of material appeared in the literature involving the isolation, synthesis, and therapeutic use of the sex hormones.

The Androgenic Substances

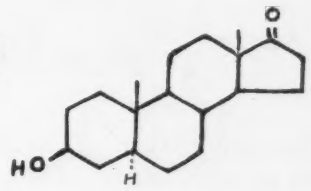
The work of Nussbaum on the frog showed that something in its testes controlled its sexual characteristics. On the basis of this and later work along similar lines Koch and Gallagher of the University of Chicago decided to isolate the *active* principle. Armed with *tons* of bull testes they proceeded to extract them, purify, re-extract, and re-extract, and ultimately arrived at a concentrate that had high androgenic activity. The course of extraction was followed by the effects of various extracts on capons. Their activity is easily measured by comb growth. A sensational effect was evinced from the medical profession upon publication,



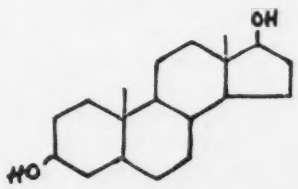
Pregnane III

Androsterone IV

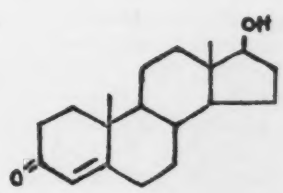
3-(α)Hydroxyetioallocholanone-17



though, oddly enough, they were cool to its medicinal value. Sex was still taboo with them. After much work on animal castrates, work on elucidation of structure was abruptly halted, since medicine had finally taken interest and requisitioned all of the concentrates. Gallagher spent the next few years manufacturing *testes concentrates* both for medicine and a doctorate. This was followed by the isolation of a pure chemical entity — 15 mg. androsterone from 15,000 liters of male urine, by Butenandt in 1931. At this point it is necessary to familiarize the reader with the nomenclature and chemical structures used in referring to the hormones. The hormones are steroidal in nature, that is, they consist of a substituted *perhydrocyclopentanophenanthrene* (I), numbered in rotation, the four rings are designated as A, B, C, D: Figure I, *etiocholane*, is the androgenic skeleton, while II is I minus carbon 18



Androstandiol VIII



Testerosterone IX

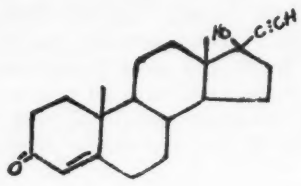
Δ⁴-etiocholene-17-(α)-ol-3-one

Herbert Kosower

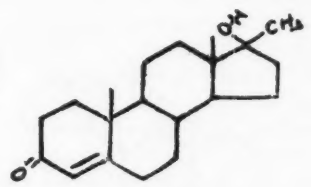
Precipitating one of the essential intermediates in the preparation of a sex hormone

(C_{18}) and ring A benzenoid, the basic estrogenic structure. Finally III with two added carbons, C_{20} and C_{21}, is pregnane, the general structure of the progestational compounds. The configuration of rings A and B differs with the hormones, and is either *cis* or *trans*, transposed to the old steroid nomenclature as *normal* or *allo*, respectively. Spatial isomerism at C_3 occurs in relation to the A and B juncture and is referred to as the α (trans) and β (cis) forms. At C_{17} the same relationship occurs with C_{19} and is designated similarly. The suffix *ene* refers to unsaturation and the position of the double bond is indicated by the number followed by the symbol Δ.

From 25 mg. of androsterone (IV), 3-α-hydroxyetio*allo*cholanone-17, Butenandt was able to arrive at the correct chemical constitution using the classical micro methods of Pregl. At this time Leopold Ruzicka attacked the problem from the preparative standpoint. Starting with cholesterol (V), he removed the double bond by hydrogenation and after protecting the hydroxyl group removed the side chain at C_{17} by vigorous oxidation. In low yield he isolated a ketone which was not androsterone but a stereoisomer. He repeated his oxidative degradation armed with the remaining (three) stereoisomers: epicholesterol, coprostanol, and epicoprostanol, and obtained the corresponding ketones, the one degraded from epicholestanol being identical with androsterone. Hence the structure of androsterone was definitely established. As Butenandt *et al.* continued their work on urine, they isolated a physiologically less active companion substance, chemically similar to androsterone save for a double bond. By oxidative degradative methods from cholesterol, and by keeping the double bond intact they isolated a ketone identical with that of the unknown substance, the structure being that of Δ^5-3(β)-hydroxyetio*allo*cholanone-17 or dehydroisoandrosterone (VII), the second male hormone. By exploring the chemical properties of these compounds Ruzicka synthesized androstandiol (VIII), by reducing androsterone, and found that it was three times as active. The problem was now becoming more complex. In 1935 when the chemical novelty of these hormones began waning, physiological tests were made in quantity with great accuracy. The various laboratories noticed that the pure hormones (IV, VII, and VIII) in any combination were not as active as urine or testicular extracts. Lacquer conducted quantitative bio-assays by administering pure hormones to a set of castrates and testicular extracts to another set. The results were truly startling. The testicular extracts were sixty-seven times as potent as the pure hormones, and the urinary extracts fourteen times as potent. The obvious deduction was that there was still an unknown hormone present, and in June 1935, David, Dingemanse, Freud, and Lacquer reported the isolation in a pure condition of a testicular hormone to which they gave the name testosterone. From 100 kg. testis tissue they isolated about 10 mg. This hormone had chemical properties similar to those reported by Koch and Gallagher, and it is now believed that they had impure testosterone. In rapid succession Ruzicka and Butenandt independently announced the synthesis of the real male hormone, testosterone (IX). For this and previous accomplishments they shared the Nobel Prize in Chemistry for 1935. As yet testosterone is the most potent androgen and although



17-Ethinyl Testosterone
XXIII



17-methyl testosterone

nearly one hundred compounds have been synthesized, the search is still continuing for a cheaper and better hormone. To date more than two hundred and fifty papers have been published directly concerning this problem.

Testosterone is manufactured commercially by the method employed by Ruzicka. Starting from cholesterol (V) in ten steps he arrived with testosterone in a yield of two per cent of the theoretical. Testosterone is used therapeutically in successfully combating some types of senility. It has been very successfully used in cases of hypertension (high blood pressure), cancer of the breast, when caught in the early stages, and a host of conditions that affect the female when an overproduction of the female hormones takes place. It also prevents some of the conditions associated with senility, mainly that of virility. It alleviates hormone sterility or other conditions due to endocrine deficiencies or maladjustments. Experiments with eunuchs have been promising in the development of the secondary masculine characteristics. Testosterone is applied either intravenously, orally, or through skin absorption with

(*Continued on page 200*)

"...AND THE LESSER LIGHT TO RULE THE NIGHT"

By PETER B. NEIMAN, '49

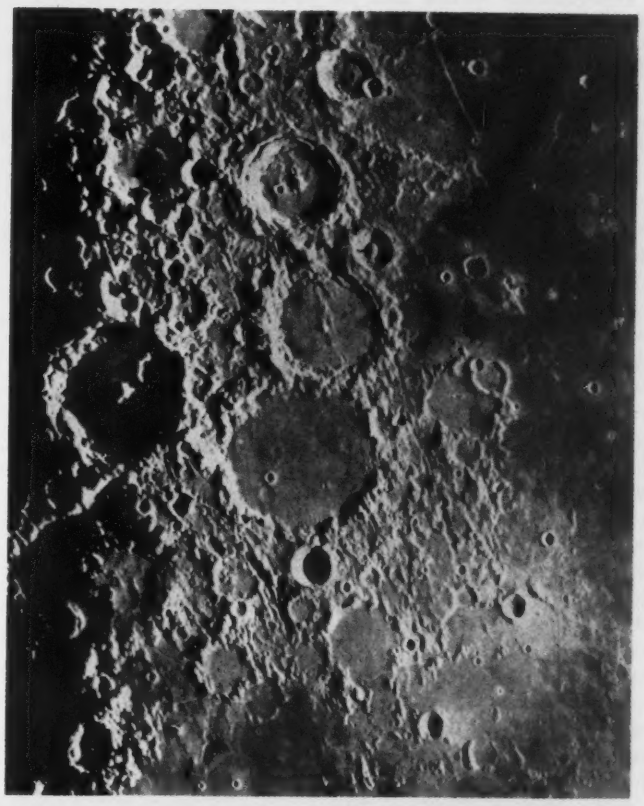
"THOTH, measurer of time, creator of Heaven and Earth, inventor of speech and writing, and recorder of a thousand years," was the Egyptian name for the Babylonian "Sin," the Greek "Diana," the Roman "Luna," and the Teutonic "Mona," or Moon. It has been a part of legend and religion since the dawn of man, and has profoundly influenced the cultural and scientific progress of civilization. Its never changing cycles around the Earth enabled early man to first grasp the concept of time, and to predict the recurrence of periodic events on Earth, such as the flooding of the Nile River. And the accuracy of these predictions determined the life and death of early man, hence the invention of mathematics and writing, with which he could record and remember the voice of the moon-god Thoth.

Since the time of Newton (whose gravitational laws were based on lunar observations), the Moon has been so exhaustively studied that many of its features, such as its topography, are more accurately known than those of the Earth. It is the only body revolving around the Earth, describing an elliptical orbit at a mean distance of 238,800 miles out. It takes 29½ days at 2,100 miles an hour to go around once. It is .013 as massive as the Earth and has a volume of .022 times that of the Earth. With a diameter of 2,163 miles, it moves across the sky its own length every hour. This combination of length of diameter and distance from the Earth has brought about one of the most amazing coincidences in scientific history. During an eclipse of the Sun, the Moon almost perfectly matches the solar disk, so that the solar corona, ordinarily undetectable in the glare of the Sun itself, leaps into view. Without this curious combination of distance and size, the solar corona, key to mystery of solar energy, might never have been known.

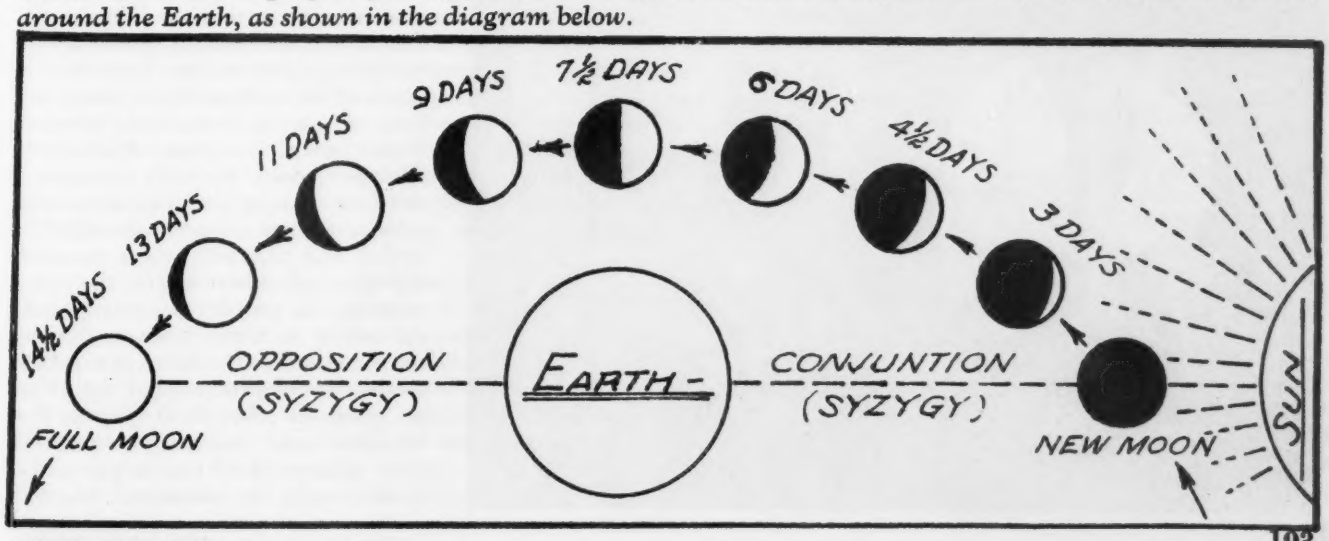
On first sight, the most striking feature of the Moon is the phases through which it passes as it makes its

(*Continued on page 216*)

A portion of the Moon's surface during the last quarter. Notice the knife-like edges of the craters, unworn by wind or water. Also notice the striking contrast between light and shadow, caused by the absence of atmosphere. It is the lack of distortion of these shadows that makes measurement of the craters possible.



In its motion around the Earth, the Moon, emerging from New, appears to rise in the West, and the Earth's rotation makes it appear to also set in the West. Its movement with the Earth, Sun and Planets is ever eastward. Its changing shapes or phases are wholly caused by its change in position in its monthly journey around the Earth, as shown in the diagram below.



Vacuum Engineering

By HERBERT KURINSKY, '48

Pictures courtesy of National Research Corporation

ARISTOTLE said that nature abhorred a vacuum. And thus far, no one has been able to dispute with him on an exact basis; for even so-called empty space contains hundreds of molecules per cubic liter. However, modern science has made it possible to come very close to showing how the old Greek theoretician was wrong. Laboratory workers have been taking gas molecules out of systems for years — in many cases, experiments could not be carried out without first removing most of the atmosphere from, for example, an electron tube. And recently, within the last decade, high vacuum, as the relative absence of gas molecules, particularly air molecules, is called, has been made available for commercial large-scale use.

Vacuum engineering is the application in practice of the "know-how" gained in low-pressure work in physical laboratories. Low-pressure, high-vacuum work is designated as such when the pressure required is in the region below 1 millimeter of mercury (or 1000 microns in current terminology). Some installations are capable of attaining 10^{-6} mm. of mercury (.001 micron).

At the beginning of the second World War, magnesium was in extremely short supply, and every available process for producing this light element was thoroughly investigated and evaluated. One of these processes was one which involved the reduction of domestic dolomite (a magnesium calcium carbonate) with ferrosilicon. Since the magnesium had to be distilled from the reduction mix, a high vacuum was necessary to lower the temperature of volatilization. And since the magnesium, especially when hot, is highly susceptible to attack by oxygen and nitrogen, then the vacuum helps to protect the metal. It has also been found that a pressure below 100 microns causes the magnesium to condense into a hard, dense material, low in impurities and difficult to ignite. Above 500 microns, the distillate contains oxide, nitride, and pyrophoric metal. If some of the sodium and potassium that is sometimes present in the original ore is also present in the condensate, these metals burst into flame on discharging the retort and ignite the pyrophoric magnesium. When working with such potentially dangerous metals, the reduction of inflammability is always an important problem. The equations for the reactions are:

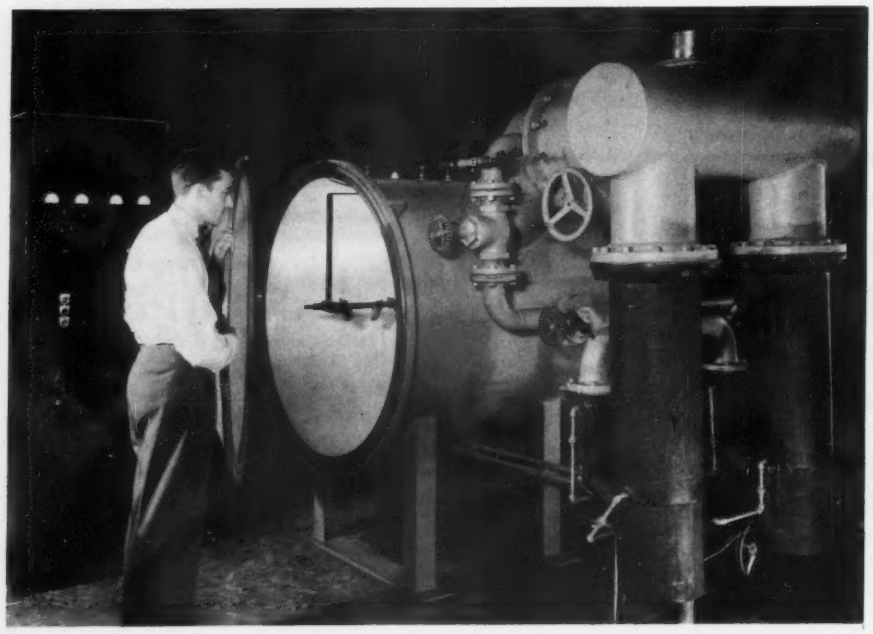
$$MgCO_3 \cdot CaCO_3 \rightarrow MgO \cdot CaO + 2CO_2$$

then,

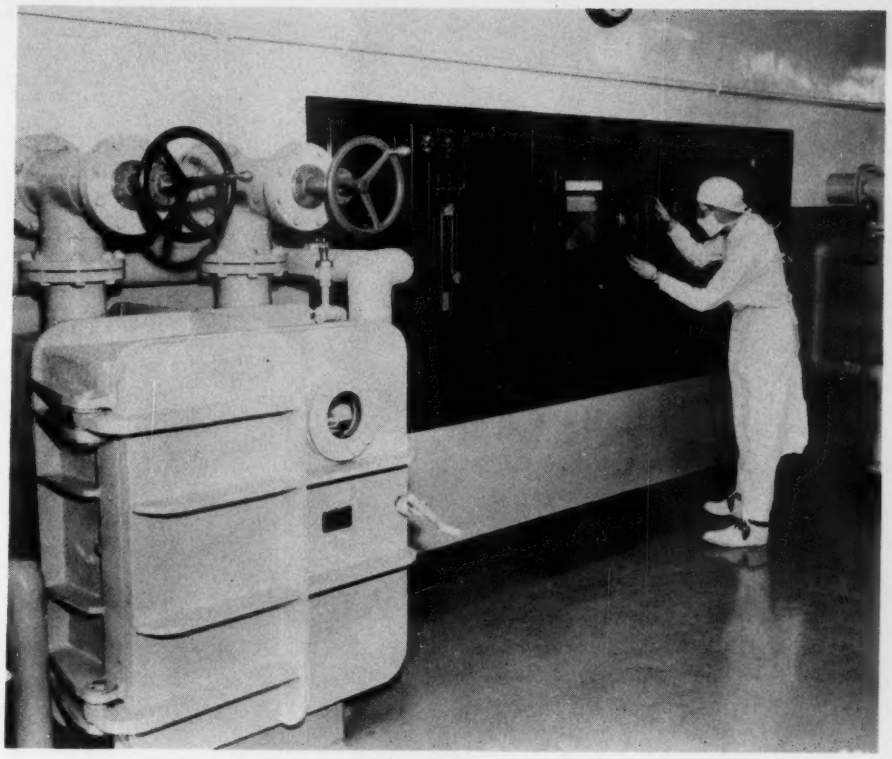
$$2(MgO \cdot CaO) + 1/6\,FeSi_6 \rightleftharpoons 2Mg + 1/6\,Fe + (CaO)_2 \cdot SiO_2$$

The operating temperature of the reaction is 2150° F. Mechanical oil pumps are used to attain operating pressures, while other types such as steam jet ejectors have found use in single units. The most efficient pump, however, is the diffusion pump, using oil or mercury as fluid. These are not able to handle equipment pressures of more than 1000 microns so that they must be used in conjunction with a mechanical forepump of the oil type. There are two types of pumps used on a bank of reactor furnaces in magnesium production. One, nicknamed "roughing" pump, removes most of the air until at the proper point (around 1000 microns) the holding pump takes over and reduces the pressure to operating pressure and holds it there, come magnesium or high pressure. The derivation of the term "roughing" is apparent: a "roughing" is a quick, relatively inefficient removal of a large amount of air; most applications on a large scale use roughing pumps to quickly attain operating pressures. Thus, high vacuum made it possible to produce large amounts of magnesium from domestic ores.

Examining a chamber used for the coating of various materials by evaporation over a hot filament in apparatus evacuated to a very low pressure by diffusion pumps.



Much of the commercial development of high vacuum techniques is due to the National Research Corporation of Boston. At present, one of their largest projects is a dehydration process for the conversion of orange juice to powder. In the research laboratory at Plymouth, Florida, a continuous vacuum-dehydrating process has been developed which reduces the water content of orange juice from around 90 per cent to less than 1.0 per cent. The procedure is really two-step; the first changes the original orange juice to a thick concentrate which is cooled and pumped into a vacuum diffusion chamber where the conversion to powder is completed. According to many tests conducted on the powder, the taste is superior to the canned product and not quite as good as the fresh juice; the ascorbic acid content is lowered only about 4–5 per cent. The powder may be dissolved in cold



A technician checks a McLeod gauge reading for equipment removing water from penicillin by a vacuum diffusion process.

water easily and it has the advantage that the total solids content of the juice may be decided. Since it is the total solids content that determines the "body" of the juice, this assures the user of full "body." The high ascorbic acid (vitamin C) retention of the powder is useful in another way: types of oranges which have an early season and a high ascorbic acid content but a poor taste may be blended with later oranges of lower ascorbic acid content but with a far better taste. The QM Corps of the Army ordered 100,000 pounds of the powder but cancelled soon after the war ended. National Research set up a subsidiary, Vacuum Foods Corporation, to build a two million dollar plant in Plymouth for the production of the orange powder.

Everyone is familiar with the story of penicillin production. How, in 1941, the antibiotic action of penicillin was brought into prominence; how within a year and a half, large factories for the production of penicillin were built and in operation; how in 1944, billions of units of the precious substance were being packaged and shipped. In order to take the concentrated sodium penicillin as it came from the final step and send it out, it had to be dried. Not only dried, but dehydrated thoroughly, and dehydration of heat-sensitive penicillin meant low-temperature dehydration. High vacuum provided the answer. By the mechanism of high-capacity oil pumps and multistage-oil diffusion pumps provided with condensers (to remove water vapor as it came off from the penicillin), a vacuum diffusion process of dehydration was put into active and productive use.

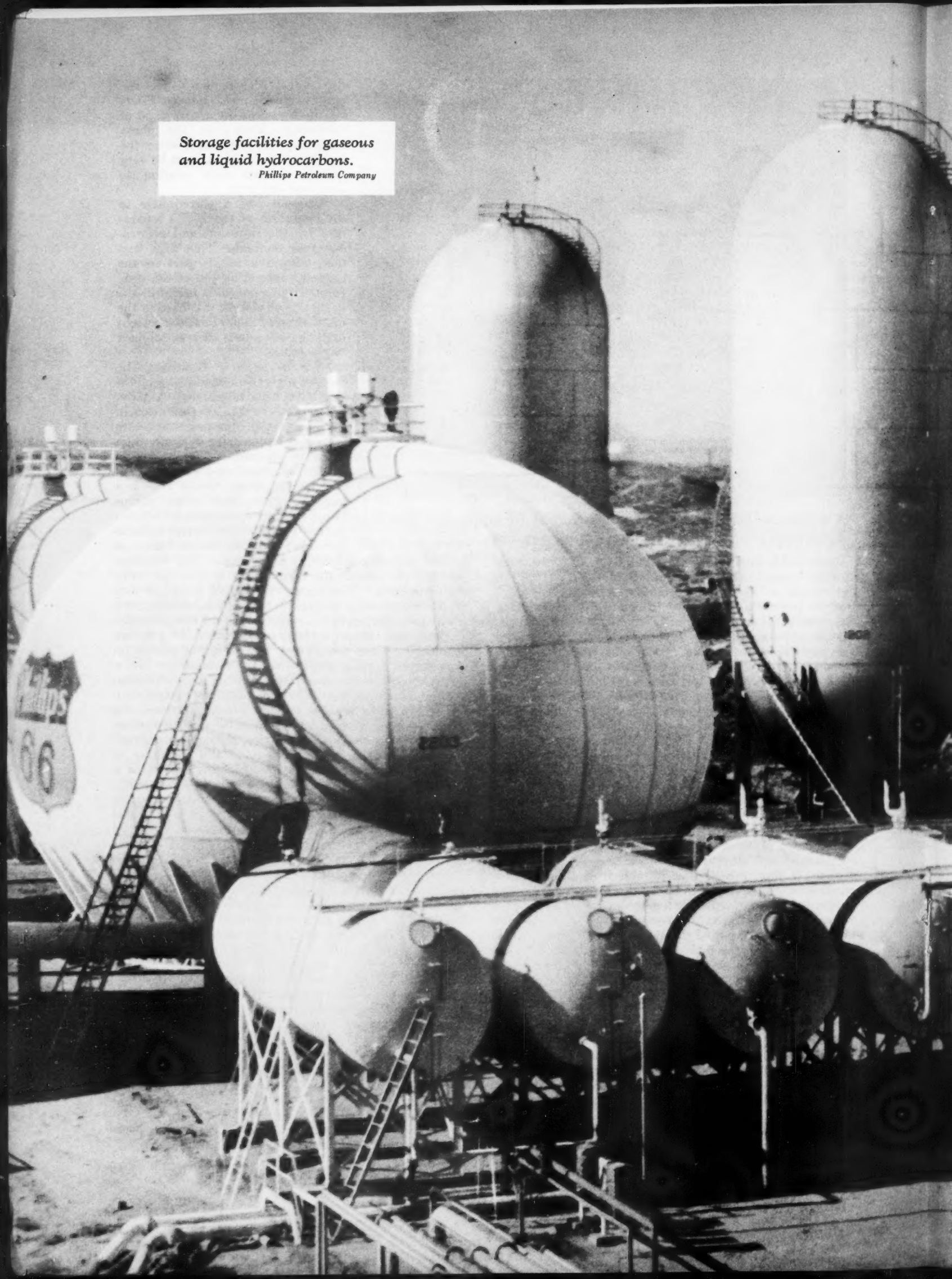
The discovery that a lens coated with a film of a thickness equal to one-quarter of the wave-length of light was actually a better transmitter of light than uncoated lenses opened a new field of application for high vacuum. Most of the lenses used by the armed services during the war were coated lenses. Coating is carried out by evaporating a metallic salt such as magnesium fluoride onto a lens surface in a chamber evacuated to about .01 microns. Coated lenses also reduce the tendency for the formation of "ghost" images. Coating of the lenses in a new type of microscope known as the phase microscope is important since the outlines of the subject must be very sharply defined with relation to their surroundings.

Vacuum was a prerequisite to the operation of the U-235 separation by the diffusion and electromagnetic methods. Thus high vacuum played a major part in the biggest engineering job of the century. High vacuum is useful in the degassing of metals; it is used in the distillation of high molecular weight organic compounds such as complex triglycerides.

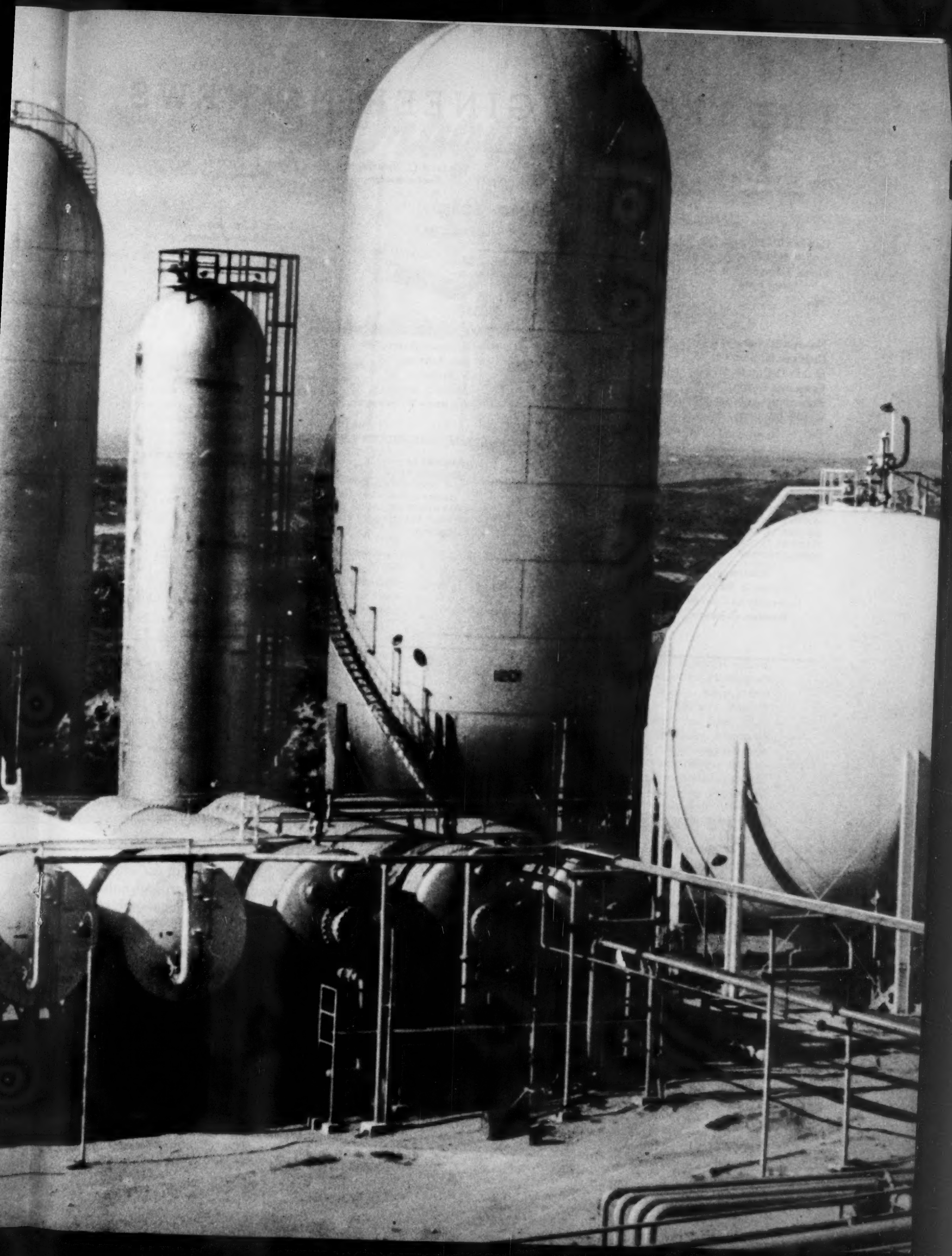
We have been discussing the uses of high vacuum, and the methods have been mentioned casually. These deserve some examination in greater detail, because they are generally applicable. For any high vacuum system, a forepump of either the rotary oil-sealed mechanical, or the steam ejector type is a must. These first stage pumps must be able to maintain a forepressure of 10 to 1000 microns in order to provide for the successful operation of the diffusion pumps in stage two. The diffusion pump is the part of the system that creates the really high vacuums. The pump consists of a casing into which heated oil or mercury vapor is projected in such a way as to entrap the air molecules of the system under vacuum and compress them to the threshold pressure furnished by the forepump. The diffusion pumps on commercial applications are usually multistage. Many systems require condensers in line ahead of the diffusion pumps (such as penicillin dehydration equipment). There are three reasons for this precaution: one, the elimination of effect of vapors from the diffusion pump on the system under vacuum; two, the condensation of vapors present in the system itself and eliminate or decrease their effect on the pumps (this applies to a lowering of the partial pressure of any system vapors); three, to act as a pump, in the case of dehydration, by pulling water from the system. One type of National condenser is mechanically refrigerated to −75° F. and contains rotary blades to scrape off the ice as it forms on the condenser surfaces. Simpler condensers are called "cold traps" and are wells cooled by dry-ice acetone mixtures. To connect all the component parts together, special valves and carefully made, all-welded piping are needed. The valves are tight down to .001 microns, as they must be. Piping was a chemical engineering problem. By complicated mathematical juggling, a correction factor for low pressures for Poiseuille's law was arrived at. It was found that an elbow had very little more resistance than the pipe itself. Determining factors, though, are speed of pumping, length of operating cycles, and ultimate vacuum desired.

Lord Kelvin, in his oft-quoted, but applicable, statement, said that we never know anything until we can measure it, and certainly that principle applies to high vacuum. There are four common ways of measuring high vacuum. The most generally applicable over a wide range is the old standby, the McLeod gauge. This gauge traps a portion of the system atmosphere

(*Continued on page 216*)



Storage facilities for gaseous and liquid hydrocarbons.
Phillips Petroleum Company



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Can You Do It?

THE SEVENTH IN A SERIES OF MONTHLY BRAINBUSTERS

THIS MONTH: Four of the Classics — All Easy!

Problem 1: Three wise men one night sleep by the roadside during a long trip. A passer-by prankishly paints their faces black during the night. The next morning, the three sages awake simultaneously and, seeing each other's faces, begin to laugh. Suddenly one of them stops laughing, for he realizes that his face is painted too. How did he reach his conclusion?

Problem 2: I have just finished tossing a coin eight times. Seven times it landed heads, and one time it landed tails. What is the probability that I will toss another heads on my next try?

Problem 3: Three men play a game with the understanding that each time a man loses he is to double the money of each of the other two players. They play three times and each man loses once. Each man is then left with $24. How much did each start with?

Problem 4: Given an eight-gallon can full of gasoline, and having only two other utensils to work with — a five-gallon can and a three-gallon can — how is it possible to divide the contents of the eight-gallon can into two equal parts?

J. W. W.

(*Answers to last month's problems are on page 208*)

The Dragon's Den

Life, Liberty, and the Pursuits of Engineers . . .

The great and growing technology of today is made possible by engineers, technicians whose job it is to understand as well as apply and put to use.

Technology is the most important consideration for those students who come to M. I. T. Why else travel or go to any pains to attend one of the toughest technical schools in the world? A man, however cold and scientific, has emotions as well as reason. These emotions arise from the foundations of family and society. They exist and act in every persons — and every Techman. Every Techman should be aware of his responsibilities to his family and his society. Most of us have a glib answer for this question whenever it comes up to annoy us, and that is: "Can't you see that we're busy being and becoming the engineers of the Earth?" But what if there is no earth to engineer, no bridges to build, no turbines needed, no engineers wanted *here?* This is not to paint the picture of desolation which the cynics try to create with visions of atomic warfare. No! This is what will happen if society falls apart inside, if there *are* no engineers wanted.

What do you think of when you think of the rest of the society of which you are a part? Do you think of labor as an instrument to a certain end or are laboring men people with the same basic needs as engineers? Are you one of those who considers labor an obstacle in the path of individual freedom? You have the army, you have Congress fighting valiantly for your "rights." Is Russia also one of those things tucked away in the cubby-hole of "not-worry"? Britain's problems are no concern of ours. Starving Europeans certainly possess little gratitude for the great liberators. Dictator Juan Peron of Argentina does not dare use any new power or weapon, even though German and Argentinian researchers develop an atomic technology. Our own white-collar worker loves to slave for the lowest possible wages; he can always have the satisfaction of knowing that America is a land of opportunity. Special interests clamor for their special requests, businessmen protest against "pink-tinged" liberals, the economic barometer fluctuates unpredictably and waits for the chance to take the longest nose dive in our history. Is that the world that you, engineers and scientists, want to live in?

Awake! Your individual interest is needed. Look at the progressive, active association of veterans — the older students who know what it means to be conscious of duties toward one's world and society. Awareness of the world is the only sane method for making possible a future for the world, and for us — the engineers. Through the mediums of the Lecture Series Committee, the MITVA, the newspapers, and your own discussions, develop your sense of social responsibility. For, as sure as you are reading this, the time is coming soon when man, all man, will need that sense.

Rebellion . . .

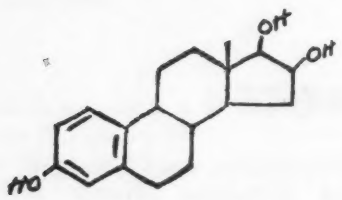
In their new role in the modern world, scientists have become vociferous in support of their views. But, few, if any, have taken the strong stand that Dr. Norbert Wiener of the Mathematics Department has. It is Dr. Wiener's firm belief that the scientists must exercise a voluntary censorship of their ideas in order to prevent their misuse by the military cliques with supernationalistic ambitions. The letter in which he expressed these opinions appeared in *Atlantic Monthly* although it was originally addressed to a research scientist working on guided missiles. ". . . practical use of guided missiles can only be to kill foreign civilians indiscriminately. . . . I do not desire to participate in the bombing . . . of defenseless peoples. . . . I do not expect to publish any future work of mine which may do damage in the hands of irresponsible militarists. . . ." Thus does Dr. Wiener state a principle of action which it might behoove other engineers and scientists to follow. Here, independence of thought and action are used in a way which is designed to benefit society by trying to slow the deadly development of military might. Whatever the final correct course will prove to be is a matter of question, but the principle remains inalterable. You must be aware of your surroundings, evaluate them, and be an active being in your *own* world.

E. M. K.

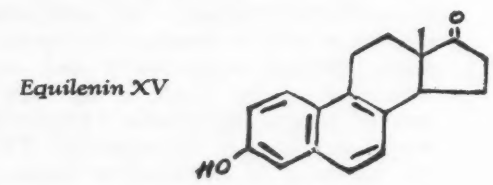
(*Continued from page 192*)

cold creams. The last method has led to a highly-lucrative pharmaceutical practice. A methyltestosterone (X), although one-third as potent, can be taken orally with much greater effect than that obtained by testosterone.

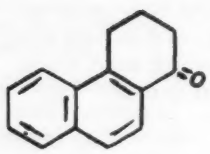
Although testosterone is the male hormone, the gonadtropin, a pituitary secretion, excites the interstitial cells which manufacture the testosterone. Therefore, administering the gonadtropin, ICSH, to eunuchs is of no avail, for the interstitial cells are gone.



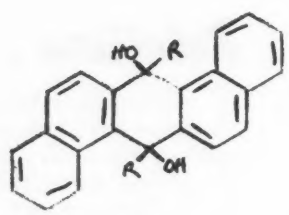
Estriol XIV



Equilenin XV



1-Keto-1, 2, 3, 4- Tetrahydrophenanthrene XVII



9,10-Dialkyl-9,10-dihydroxydibenzanthracene XVIII

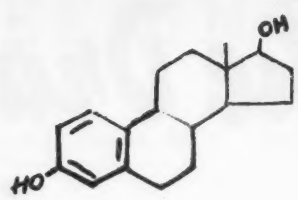
When R = isopropyl, .5 mg gives estrus response. Most active in the series.

The Estrogenic Substances

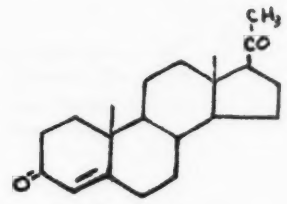
In order to fully understand the means of isolation and the biological end of the female sex hormones it is necessary to first understand the biological changes through which part of the female's sex organs undergo periodically. In the lower forms of animal life the female is brought into a period of heat, called estrus, during which she will mate. In estrus, rats, mice, and similar mammals show characteristic changes along the lining of the vagina, corresponding to the phase she is in. By microscopic examination of the vaginal smears the estrus condition can easily be recognized. By using castrated female rats Allen and Doisy adopted this biological phenomenon as a means of assaying estrogenic activity.

In the human female the sex cycle is about twenty-eight days long and there is no estrus period. It is started by the action of FSH, a gonadtrophic secretion of the pituitary, a follicle-stimulating hormone which causes the growth of a follicle in the ovary. About the fourth day of development the ovary starts to manufacture the estrogenic substance estradiol (XI) which inhibits the effects of FSH, and also promotes the growth of the uterine endometrium (lining). The lining continues to proliferate and the follicle continues to develop. At about the fourteenth day ovulation takes place, that is, the follicle is discharged from the ovary and makes its way to the uterine endometrium. The pituitary luteinizing hormone which affects mammary development and the production of the corpus luteum hormone from the corpus luteum (the follicle now in the uterine endometrium) now comes into play. The female is now in a receptive state for fertilization. If this

(*Continued on page 202*)

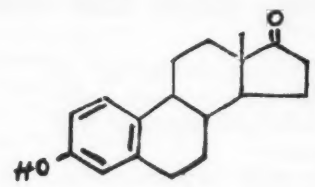


Estradiol XI

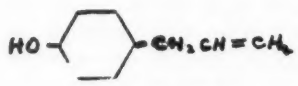


Progesterone XII

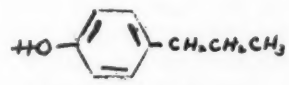
3,20-Diketo-Δ^4-pregnane



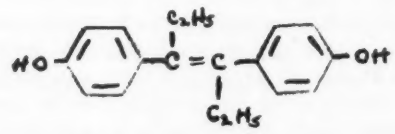
Estrone XIII



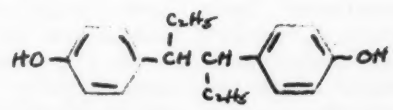
Anethole XIX



p-Propylphenol XIXa

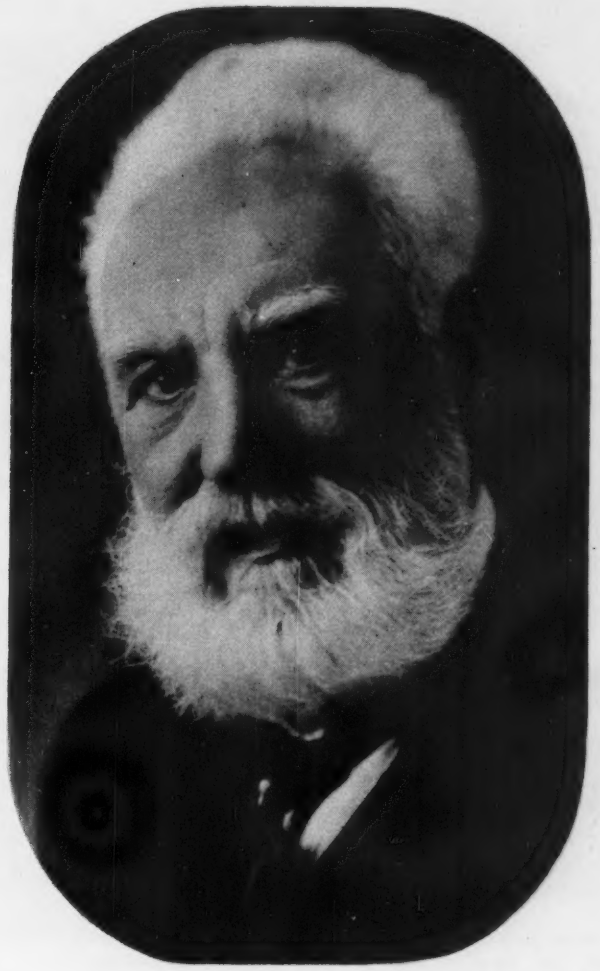


Diethylstibesterol XX



Hexesterol XXI

He gave the world a new voice



ALEXANDER GRAHAM BELL
by Moffett, 1918.

Alexander Graham Bell was a teacher of the deaf. He was also a trained scientist who made it possible for millions upon millions of people to hear each other by telephone.

The telephone brought something into the world that had not been there before.

For the first time people were able to talk to each other even though separated by long distances.

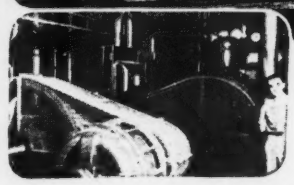
Horizons broadened. A new industry was born, destined to employ hundreds of thousands of men and women and be of service to everyone in the land.

Alexander Graham Bell was a great humanitarian, not only as a teacher of the deaf, but in his vision of the benefits the telephone could bring to mankind.

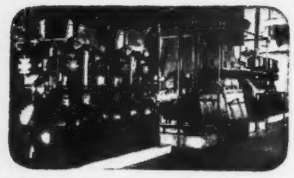
Bell's vision has come true. It keeps on being an essential part of this nation-wide public service.

BELL TELEPHONE SYSTEM

Three Large Frick Machines Serve This Synthetic Rubber Plant at Institute, W. Va.


Frick Refrigeration Aids Two St. Louis Firms in Making Films.

The Celanese Corp. of America Has Used These Frick Machines Since 1929.


4900 Tons of Frick Refrig. Air Condition The Caterpillar Engine Works at Peoria, Ill.

Indispensable in Industry

FRICK Refrigeration

Whether you operate a chemical, textile, metal working, or food processing plant, you can likely do it better—give better service and earn better profits—with the aid of Frick refrigerating, ice making, or air conditioning equipment.

Because Frick equipment is readily adapted to meet any industrial or commercial need. You simply pipe it to the point of use. Any temperature between 80 deg. above and 130 deg. below zero, F. can be maintained — automatically if you wish. Write for literature.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, now in its 30th year, is approved under the G.I. Bill of Rights.

FRICK CO., Waynesboro, Pa.

MOLECULES OF LIFE

(Continued from page 200)

does not take place by the twenty-seventh or twenty-eighth day, the production of the female hormone ceases, the corpus luteum degenerates, and menstruation ensues, and the cycle is then repeated. If, however, fertilization took place, the production of estrogenic material would almost cease, and the production of the corpus luteum hormone, progesterone (XII), would increase, maintaining the female in a pregnant state. A deficiency in progesterone eventually leads to abortion.

The study of the female sex hormones began in 1923 when Allen and Doisy succeeded in obtaining estrogenic concentrates from sow's ovaries, testing their preparations by using the vaginal smear test. It was later found that the urine of pregnant women and mares, or the urine of stallions is rich in the source of this material. The estrogenic concentrates yield estrone (XIII) which was obtained independently by Doisy and Butenandt in 1930. By international agreement the potency was expressed in mouse units (M.U.) equal to 0.1 micrograms of estrone. Table I shows the estrogenic contents of urine from various sources. A second compound, estriol (XIV), was isolated by Marrian a few months later. The structures of these compounds were determined by the combined efforts of the German and English workers with the use of such tools as X-ray diffraction, selenium dehydrogenation, absorption spectra, and the synthesis of a large number of degradation products. A total synthesis of equilenin (XV) by Bachman confirmed all structures, because estrone is easily converted into it without any change in ring size. A product formed by

TABLE I

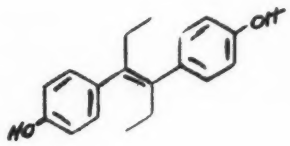
CONTENT OF ESTROGENIC HORMONE OF VARIOUS URINES

M.U. = Mouse Units

	Normal		Pregnant	
	M. U. per Liter	*M. U. per Diem*	*M. U. per Liter*	*M. U. per Diem*
Woman	425	600	21,000	31,000
Man	160	240		
Mare	200	2,000	100,000	1,000,000
Stallion	170,000	1,700,000		
Zebra(male)	36,000			
Bull	330			

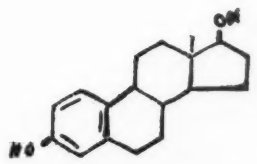
the reduction of estrone is estradiol, nearly ten times as active. Doisy isolated it from sow's ovaries in 1935. In all six compounds have been obtained from natural

(Continued on page 204)



XX written in steroid form XXII

Estradiol XXIIa



Kodak

A TENSE MOMENT in the September, 1946, title bout between middleweight champion, Tony Zale (left), and top-ranking challenger, Rocky Graziano.

Because photography is graphic . . .

YOU KNOW how photography brings out the drama and excitement of a prize fight. But do you know how it can be used to bring out the drama and excitement of ideas . . . products . . . processes . . . technics?

With motion pictures, you can put new life, spark, interest in the presentation of any idea or product. You have color, sound, and action . . . and can get quicker and greater acceptance through your showmanship.

The whys and wherefores of basic processes and technics can be graphically explained with films . . . training programs made more understandable, more interesting, and, therefore, more productive.

Beyond these, there are many other business and industrial uses to which other phases of photography can be applied. For a brief and interesting description of some of these uses, write for booklet—"Functional Photography." It is free, of course.

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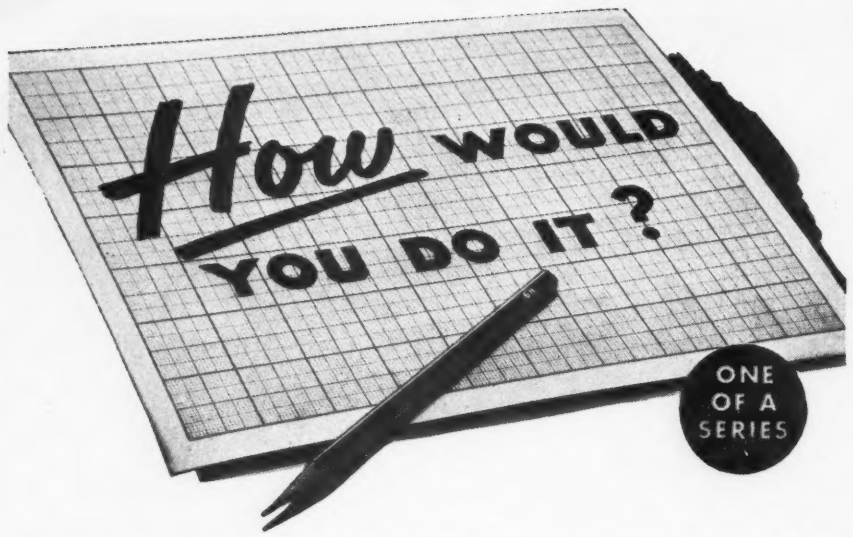
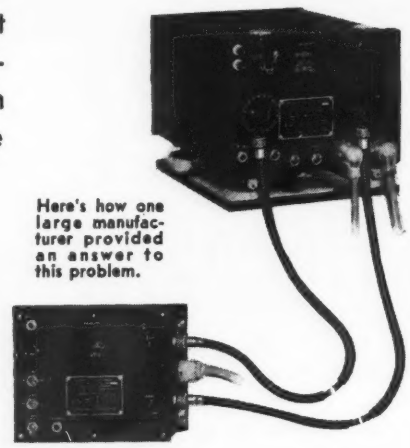


PROBLEM—You have an aircraft radio receiver. To operate it, the band selector and tuning elements must be adjusted. You want to arrange it so that these adjustments can be made right at the receiver or from a remote point. How would you do it?

THE SIMPLE ANSWER—Use S. S. White remote control flexible shafts to connect the tuning dials on the receiver to tuning cranks on a remote control unit. This arrangement leaves you free to mount the control unit anywhere you want, and assures you of smooth, sensitive tuning from any distance up to 50 feet or more. The shafts can be readily run around turns, along walls, under flooring as conditions in different aircraft may require. Any required degree of sensitivity can be obtained by connecting the shaft through simple gearing.

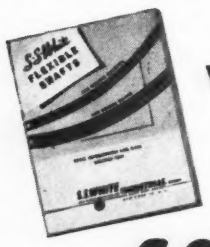
* * *

This is just one of hundreds of remote control and power drive problems to which S. S. White flexible shafts provide a simple answer. That's why every engineer should be familiar with the range and scope of these "Metal Muscles"* for mechanical bodies.



Here's how one large manufacturer provided an answer to this problem.

*Trademark



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It gives essential facts and engineering data about flexible shafts and their application. A copy is yours free for the asking. Write today.

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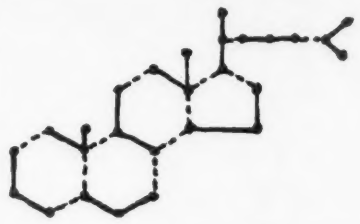
MOLECULES OF LIFE

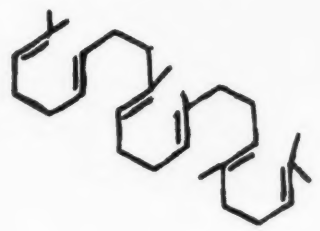
(*Continued from page 202*)

sources which possess estrogenic activity. They are all metabolic end products of estradiol metabolism, and it has been proved beyond all doubt that estradiol is the true estrogenic hormone.

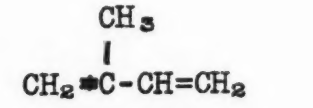
Estradiol controls and maintains the development of the uterus, vagina, mammary glands, and the corresponding curves and characteristics which are considered feminine. The female has much use for therapeutically administered estradiol. Hypofunction of the ovaries, the



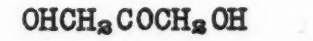
Schematic biochemical formation of steroids from simple sugars XXVb



Squalene $C_{30}H_{50}$ *XXIV*



Isoprene C_5H_8 *XXIVa*



Dihydroxyacetone XXV

site of estradiol manufacture, can be easily corrected through estrogenic therapy. It is strikingly beneficial to women undergoing the menopause, or change in life, by relieving the distresses that are associated with the condition, such as nervousness, migraine, etc. The aging woman can therefore benefit greatly from this new wonder drug. Acne, a condition not uncommon to male and female adolescents, can be conveniently cleared up in most

(*Continued on page 206*)

No moisture can seep through the seams of these raincoats—thanks to the electronic sewing machine developed at RCA Laboratories.

A sewing machine...without a needle or thread!

Since mankind first began to sew, say 15,000 years ago, seams have always meant "needle and thread."

But when new thermoplastic materials came along—specially developed for waterproof coverings such as raincoats—ordinary "needle and thread" seams wouldn't do because of their tiny holes.

Now—thanks to research at RCA Laboratories—goods made of thermoplastics are "sewn" by electrons and the seams are as strong as the material itself!

This will make possible dozens of brand-new uses for these inexpensive and durable thermoplastic materials. Even today they provide perfect packages for foods, meats and drugs because they are completely watertight, airtight and transparent. You've probably seen thermoplastic raincoats, tobacco pouches, shower curtains . . .

Research, such as resulted in the electronic sewing machine, is reflected in all RCA products. When you buy an RCA Victor radio or television receiver or anything bearing the name RCA, you enjoy a unique pride of ownership in knowing that you possess one of the finest instruments of its kind that science has yet achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20 . . . Listen to The RCA Victor Show, Sundays, 2:00 P.M., Eastern Time, over the NBC Network.

The electronic sewing machine "welds" seams in thermoplastic materials. Anyone interested in manufacturing this instrument can obtain information by simply writing to RCA, RCA Building, Radio City, New York 20, N. Y.

RADIO CORPORATION of AMERICA

MOLECULES OF LIFE

(*Continued from page 204*)

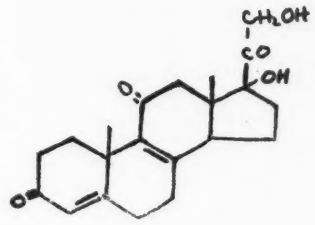
female cases by the use of the estrogens. It might truly be a man's condition.

Estradiol is commercially prepared from stallions' urine by a long and tedious process. It is because of this that the market price hovers about seventy dollars per gram. E. C. Dodds, while experimenting with synthetic carcinogens, discovered that some of them possessed estrogenic activity. Compounds such as XVII, XVIII, XIX were found to be active. Reduction of XIX yielded a mixture that was highly estrogenic. From the mother liquors the compound diethylstilbesterol (XX), as active as estradiol, or ten times as active as estrone, was obtained. It was an accidental discovery, for Dodds was just trying to reduce (XIX) to the saturated compound (XIXa). Diethylstilbesterol was later synthesized and is now being manufactured commercially. A host of compounds have been prepared of which hexesterol (XXI) is just as good as diethylstilbesterol, the others all falling below in activity. There is no hard and fast rule for predicting estrogenic activity, even though there is some similarity between diethylstilbesterol (XXII) when written to steroid fashion to that of estradiol (XXIIa).

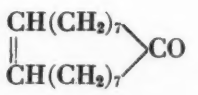
The one bad feature of estrogenic treatment is the side reactions — nausea, dizziness, and a tendency to vomit. Internal changes are that of degeneration of the liver and the fall in red blood cells when excesses are taken. There are no such occurrences when either the androgenic or progestational hormones are used. Just recently a new estrogen meprane was announced which does not possess any of these disagreeable properties. The structure has not yet been disclosed.

(*Continued on page 208*)

$OHCH_2CHOHCHO$ *Glycericaldehyde XXVa.*

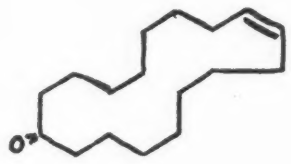


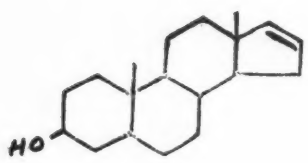
$\Delta^{4,8(9)}$-*Pregnadiene-17, 21-diol-3, 11, 20-trione XXVI*



Civetone XXVII

Civetone written insteroid form

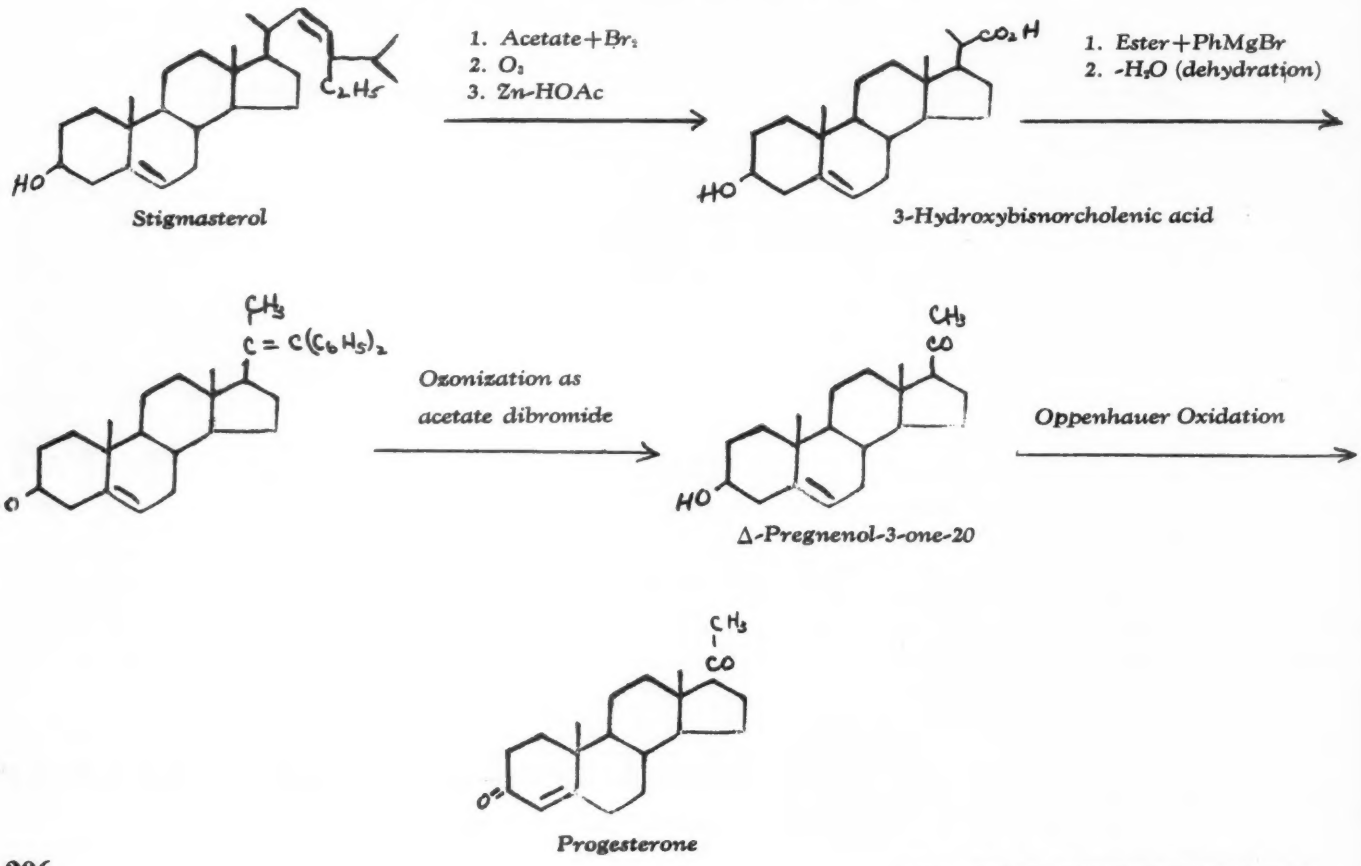




Δ^{16}-*androstene-3-ol XXVIII*

alpha epimer possesses strong musk odor

Figure I. Progesterone from Stigmasterol



Stigmasterol

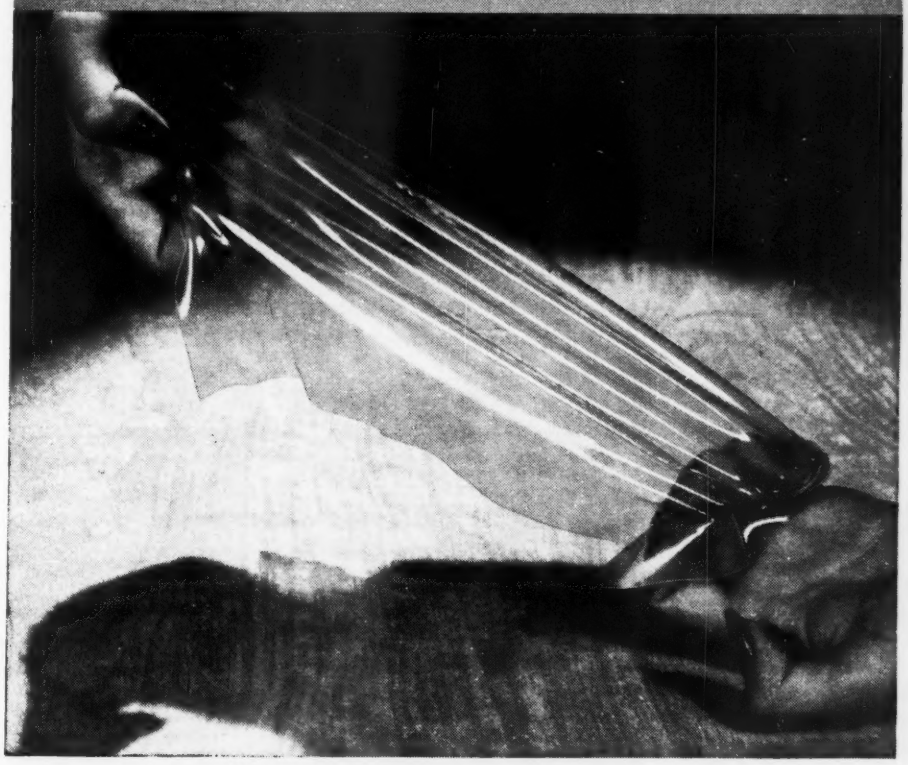
3-Hydroxybisnorcholenic acid

Δ-Pregnenol-3-one-20

Progesterone

Researchers develop unique coating material

DOW LATEX 512



Unmodified films of Dow Latex 512 are strong and highly elastic.

Students majoring in chemistry will find much to interest them in our new coatings laboratory where technicians are developing significant new materials through research. Dow Latex 512, recently introduced, is a good example of what goes on in this laboratory which is an activity of the Dow division devoted to resins, latices and plasticizers.

Dow Latex 512 is a coating material that promises great usefulness in the paint, paper, textile and adhesive industries. Its principal film forming ingredient is based on a copolymer of styrene and butadiene. On air-drying it forms a rubbery, protective film. It is compatible with conventional coating materials and possesses good stability under agitation and freezing, excellent pigment-binding characteristics and high protective values.

Dow research is continuous in all divisions and there are many fields for young technicians who are preparing for this type of work.

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CHEMICAL COMMENTS

Flexible Heat for Paint Processing

Flexible heating systems are a necessity to many paint and varnish firms, where high-temperature processing requirements vary widely. In one Midwest finishes plant, where processing temperature requirements vary from simple heating to complex sequences of heating and cooling, Dowtherm, the high-temperature, low-pressure heat transfer medium has been installed. With this indirect heating system they have found that temperatures can be adjusted easily for every specific job. The company uses a 3,000,000 Btu/hr. Dowtherm vaporizer for heating and an independent liquid-phase Dowtherm cycle for cooling. Simple controls permit the two cycles to be coordinated for a variety of temperature combinations. (Since installing the Dowtherm system, the company has found that heating is more efficient, processing more uniform, equipment is simpler and larger batches can be processed at a time.)

Disinfectants Produced from Phenol Derivatives

Phenol derivatives are now being used in the manufacture of many disinfectants. These phenol products, produced by Dow, are known as Dowicides. They are noted for their high germ killing powers which are largely retained in the presence of organic matter. Other important properties: excellent compatibility with cresols, pine oils, soaps, low toxicity, and absence of color and odor. These qualities indicate the wide adaptability of Dowicides to the manufacture of bactericides and fungicides.

Mold in Foods Prevented by Dow Propylene Glycol

The food industry is making increasing use of low-cost Dow propylene glycol to keep many types of eatables palatable and healthful, without risk of mold. . . . This is a highly purified material of pharmaceutical quality, free from odor and taste. . . . By adding small quantities of Dow propylene glycol, food processors can prolong freshness in foods—retain full flavor—and actually decrease danger of mildew.

DOW

CHEMICALS INDISPENSABLE
TO INDUSTRY AND AGRICULTURE

Answers to last month's

Can You Do It?

Problem 1: A little thinking will show that the tumbler will be full in one hour and fifty-seven minutes — three minutes short of the two hours taken by the single amoeba. This is simply because, starting with two amoeba, you begin three minutes later along the exponential series that describes the original amoeba's actions. Otherwise the two cases are identical.

Problem 2: After the original shock wears off, this one is easy also. Observe that although there are five digits in the quotient, only three products have been formed with the divisor. Thus two of the five figures in the quotient must be zeros. Obviously, the first digit is not zero, the third digit is given as eight, and the last digit cannot be zero since there is a division occurring at the last place. Thus we conclude that the quotient must be *080*. Now observe that the divisor forms a two-digit product when multiplied by eight, and that when multiplied by either the first or last digits of the quotient it forms a three-digit number. The quotient can only be 90809. Now then, what number gives a two-digit product when multiplied by eight and a three-digit product when multiplied by nine? The divisor can only be twelve. Easy?

J. W. W.

MOLECULES OF LIFE

(*Continued from page 206*)

The Progestational Hormone

In the female sex cycle progesterone, the corpus luteum hormone is manufactured as soon as the corpus luteum, or yellow body, has formed. The isolation of progesterone was made possible by Corner and Allen through the development of a biological test to ascertain its activity. The Aschheim-Zondek Test was later developed using rabbits and is exceedingly accurate. Following the Allen test, Allen isolated potent concentrates from the corpus luteum of pregnant mares, but Butenandt[32] was the first to announce the isolation of the pure hormone and also the first to synthesize it. A later synthesis by the late Fernholz, starting with stigmasterol from soya bean, is used today. The following series of reactions fully explain themselves (Figure I). Along with progesterone were obtained about twenty other products, all metabolic products in the pregnane or *allo*pregnane series, substituted in the three and twenty positions with stereochemically active hydroxyl or keto groups. Progesterone is the only pregnancy hormone. An ethinyltestosterone (XXIII) is a synthetic product which has only slight progestational properties. Progestational therapy is useful in relieving post labor pains, giving striking relief within 15–20 minutes after administration. It is also used in corpus luteum hypofunction, that is, if manufacture of progesterone cannot be maintained. Progesterone has been found useful during pregnancy, when the progesterone level drops and abortion is threatened.

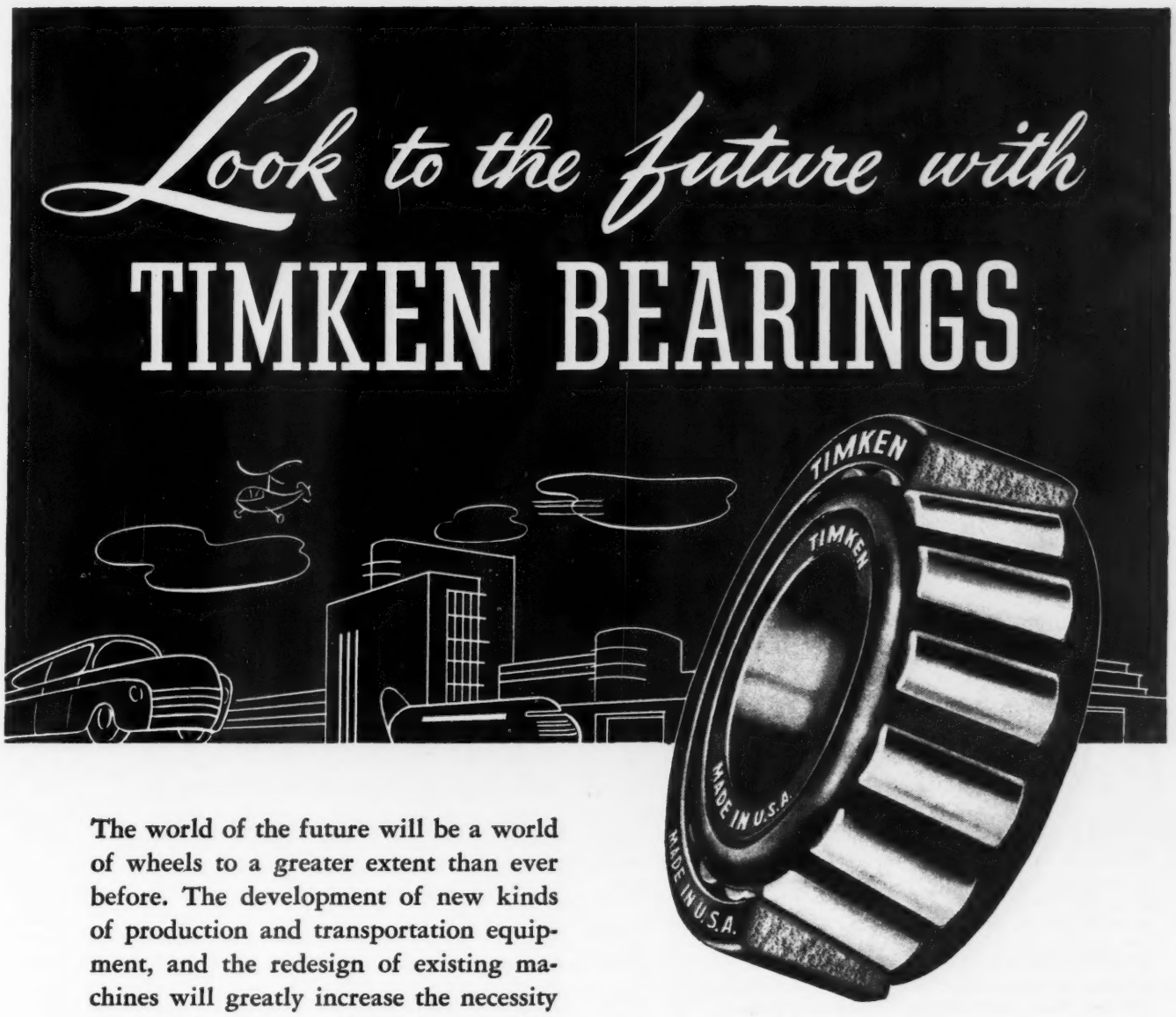
Biogenetic Relationships

Many mechanisms have been put forth to explain the biochemical formation of the steroids, but to date none have been accepted. It was thought in earlier speculations that squalene (XXIV), isoprene (XXIVa), and carbohydrates were possible precursors of the sterols. In a later hypothesis, the existence of the biochemical formation of the sterols (cholesterol) was assumed and schemes were devised to show how they were degraded *in vivo* to the bile acids and the sex hormones. Pregenolone and dehydrosterone were regarded as the chemical degradation products, and with these as the intermediates they could be conceivably led to the related hormones. Reichstein advanced a more flexible theory which suggested that three carbon carbohydrates such as dihydroxyacetone (XXV), and/or glyceric aldehyde (XXVa) may condense as in (XXVb). Marker postulated the adrenal cortex hormone (XXVI) as the common precursor of the sex hormones.

Two of the outstanding publications dealing with the biogenetic formation of the sterols used tracer elements: Sodium deuteroacetate was administered to rats and the cholesterol obtained contained enough deuterium to prove that the sterol was synthesized from small molecules (acetic acid?). In the other experiment deuterocholesterol was administered to females during the eighth month of pregnancy and the progesterone formed contained an amount of deuterium in proportion to the cholesterol level in the blood. Thus we have proved that the sterols and hormones are made from

(*Continued on page 214*)

Look to the future with TIMKEN BEARINGS



The world of the future will be a world of wheels to a greater extent than ever before. The development of new kinds of production and transportation equipment, and the redesign of existing machines will greatly increase the necessity for and importance of bearings capable of meeting new conditions of speed, precision, load capacity and endurance.

Then the same bearings that have consistently and successfully anticipated so many revolutionary developments for more than 48 years, again will rise to the occasion with the same versatility and efficiency — Timken Tapered Roller Bearings.

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BROWN & SHARPE TOOLS

CHEMICALS FROM PETROLEUM

(*Continued from page 187*)

available for years; this same product has also been prepared from petroleum within the last decade. Pure ortho-xylene, however, is of very recent origin. To date, its only significant use has been in phthalic anhydride manufacture, but in time it should find still other outlets as a chemical intermediate.

Toluene

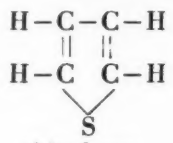
Toluene from petroleum, like cyclohexane and ortho-xylene, has been made possible by new distillation methods. In brief, the process consists of the preparation of a toluene-rich feed of narrow boiling range by straightforward, efficient fractionation of especially prepared stocks followed by either *extractive distillation* employing phenol, cresol, a sulfolane, etc., as an entraining agent or by a liquid-liquid, countercurrent extraction with sulfur dioxide or other extractive agents.

The term "extractive distillation" was introduced several years ago as a name for the unit operation of distillation in the presence of a solvent which becomes the least volatile component of the mixture and is selected to produce an enhancement in the relative volatility of the component to be separated. Like other distillation operations, extractive distillation employs a column having provisions for intermediate feed, reflux and reboiling, but in addition uses a selective solvent introduced in the upper part of the column so that the liquid flowing down is a solution of reflux in solvent. The top product is essentially one feed component and the bottom product a solution of the other feed component in the solvent. The latter feed component is separated from the solvent in an ordinary distillation column and the solvent is recycled to the extractive distillation column. The phenomenon depends on different deviations from ideality for the two components in the added solvent and thus the two components to be separated must themselves be of different types.

Under favorable operating conditions, it is believed that toluene produced from petroleum by extractive distillation will be able to hold its own with toluene obtained from coal tar.

Thiophene

Thiophene, a reactive and versatile chemical, whose formula appears below, occurs as an impurity in benzene derived from coal tar and it may be separated from the benzene by means of sulfuric acid extractions, because of the fact that it is more easily sulfonated than benzene.

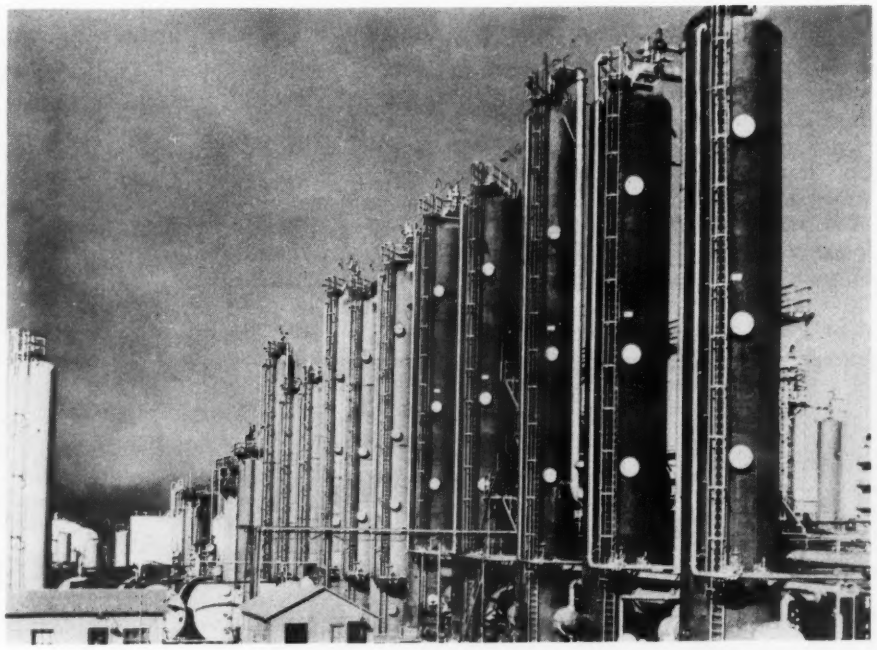


thiophene

Up until the spring of 1946 this was practically the only method of obtaining thiophene, and the price was sky-high, since thiophene is present in crude benzene only to the extent of 0.1 per cent. Then the Socony-Vacuum laboratories published a process which employs the reaction between butane and elementary sulfur to produce thiophene in 50–75 per cent yields. The sulfur is vaporized, the sulfur vapor and the butane are heated separately to about 600° C., and introduced rapidly

(*Continued on page 212*)

A natural gasoline superfractionation plant capable of producing narrow range hydrocarbon fractions.



Du Pont *Digest*

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

The "Whitest of White" Pigments from Black Ore

It is a strange fact that the ninth most prevalent element in the earth's crust should have been regarded as "rare" for over a hundred years after its discovery in 1791. But that is the story of titanium, actually more abundant than zinc, copper, lead, tin, and nickel combined. One of the factors that have kept titanium from being better known is the difficulty of handling some of its compounds commercially.

If, as a student, you were to look up the equations for the manufacture of titanium oxide pigment, you might find something like this:

$$FeTiO_3 . nFe_2O_3^* + (3n+3)H_2SO_4 \longrightarrow Ti(SO_4)_2 + FeSO_4 + nFe_2(SO_4)_3 + (3n+3)H_2O$$

$$Fe_2(SO_4)_3 + 2H^+ \longrightarrow 2FeSO_4 + H_2SO_4$$

$$Ti(SO_4)_2 + (x+2)H_2O \longrightarrow TiO_2.xH_2O + 2H_2SO_4$$

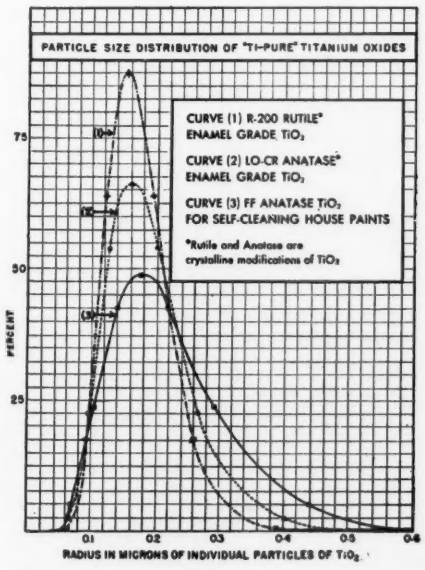
$$TiO_2.xH_2O \longrightarrow TiO_2 + xH_2O$$

*—The exact composition of ilmenite varies with the source of the ore.

From these equations, the manufacture of the "whitest of white" pigments from black ilmenite ore appears to be chemically simple and straightforward. However, the processing required to obtain industrial titanium oxide of sufficient brightness, hiding power and fineness is more complicated than one would anticipate.

Controlling a Metastable System

The final product must have a particle size averaging 0.2 microns in radius and varying between 0.1 and 0.5 microns.

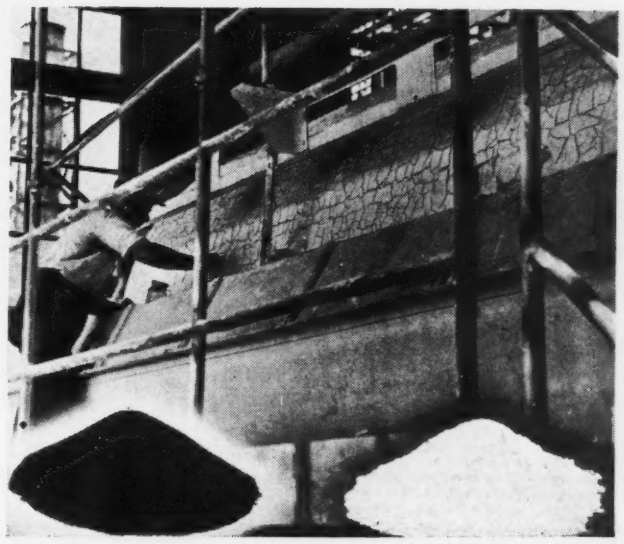


To attain this end in a metastable system that is ready to go in the wrong direction at any time requires exceedingly rigid control conditions throughout.

The essential steps in the operation are: 1) The careful solubilization of ilmenite in concentrated sulfuric acid to avoid hydrolysis. 2) The complete reduction of any ferric iron to facilitate purification of the solution, with removal of any unconverted residue and colloidal slimes. 3) Crystallization of 70 per cent of the iron as $FeSO_4.7H_2O$—a critical operation in which temperature must be kept low and wild seed crystals avoided. 4) Hydrolysis around 105-109° C.—the most important step of all—because the initial particle size and pigment properties of the final product depend on concentration, temperature, time of hydrolysis, intensity of stirring, and presence of foreign materials. In this operation it is not unusual to talk in terms of parts per million, rather than the usual analytical accuracy of 0.01-0.02 per cent. 5) Varying salt treatment of the precipitate, depending on the impurities. 6) Calcination between 900-1000° C. to obtain the desired particle size. 7) Grinding to give the proper aggregate size. 8) Treatment of the dried pigment in various ways depending on end use; e.g., in the automotive, rubber, ceramics, paper, linoleum, printing, or other fields.

Wide Diversity of Research Problems

Long and patient research was necessary to develop the manufacturing techniques now used. Some of the problems demanded technical skill of the highest order from the colloid chemist, the physical chemist, the analyst, the crystallographer, the physicist, and other specially trained men. A wide variety of instruments, such as the petrographic microscope, the electron microscope, x-ray diffraction unit, ultra-centrifuge, and spectrophotometer were used in this work. Finally the metallurgist, the chemical engineer, the mechanical engineer, and the industrial engineer had to design equipment to handle this extremely corrosive system economically.



Ilmenite (left). Titanium Dioxide (right). Apparatus in the background is a rotary filter.

The manufacture of titanium pigments is another example of the problems that constantly challenge chemists, engineers and other specialists.

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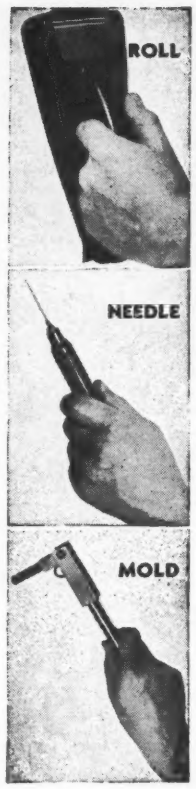


Moisture Indicators and Recorders • Physical Testing Instruments
Surface Pyrometers • Laboratory Instruments for A. C. & D. C. • Galvanometers
Engineering Instruments • Gas Analysis Equipment • Physiological Instruments
and many other Mechanical and Electrical Instruments

CHEMICALS FROM PETROLEUM

(*Continued from page 210*)

through a mixing nozzle into a reactor tube at 600°, with reaction allowed for only a fraction of a second. The product stream is rapidly quenched with a spray of water. The reactions involved appear to lead stepwise to the formation of thiophene:

$$C_4H_{10}+\tfrac{1}{2}S_2\rightarrow C_4H_8+H_2S$$
$$C_4H_8+\tfrac{1}{2}S_2\rightarrow C_4H_6+H_2S$$
$$C_4H_6+S_2\rightarrow C_4H_4S+H_2S$$

In other words, the butane is dehydrogenated to butene, and this to butadiene, which reacts with the sulfur to form thiophene. A prerequisite to the formation of the thiophene ring is a linear chain containing at least four carbon atoms. *n*-Butane will give thiophene, but *iso*-butane will not; *n*- or *iso*-pentane will give methyl thiophenes, and all of the aliphatic hexanes will give dimethylthiophenes or ethyl thiophenes. Hydrocarbons lower than C_4 do not yield thiophene but can be dehydrogenated to olefins. Methane forms principally carbon disulfide.

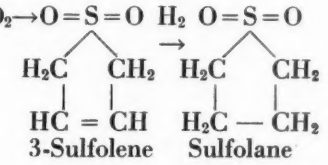
Response to the announcement of the Socony-Vacuum thiophene process has been shown from practically every branch of industrial chemistry, indicating that a host of new products including pharmaceuticals, dyestuffs, insecticides, rubber chemicals, petroleum additives, textile chemicals, resins and elastomers await development. There is no reason why in time, the chemistry of thiophene may not be just as significant as that of benzene, for the two are very similar in their properties, and thiophene is even more reactive, so that the use of mild catalysts and reaction conditions are permitted. It is readily nitrated, sulfonated, halogenated, mercurated and aminomethylated with formaldehyde and ammonium chloride.

Sulfolanes

The sulfolanes are new solvents developed by the Shell Oil Company during the war years for a variety of separation processes. They are the hydrogenated forms of diolefin-derived sulfones; the name "sulfolane" was coined for convenient use in designating the parent ring structure of these compounds in view of the cumbersome nature of the ordinary nomenclature. Sulfolane is made as follows:

$$CH_2=CH-CH=CH_2+SO_2\rightarrow O=S=O \quad H_2 \rightarrow$$

Butadiene



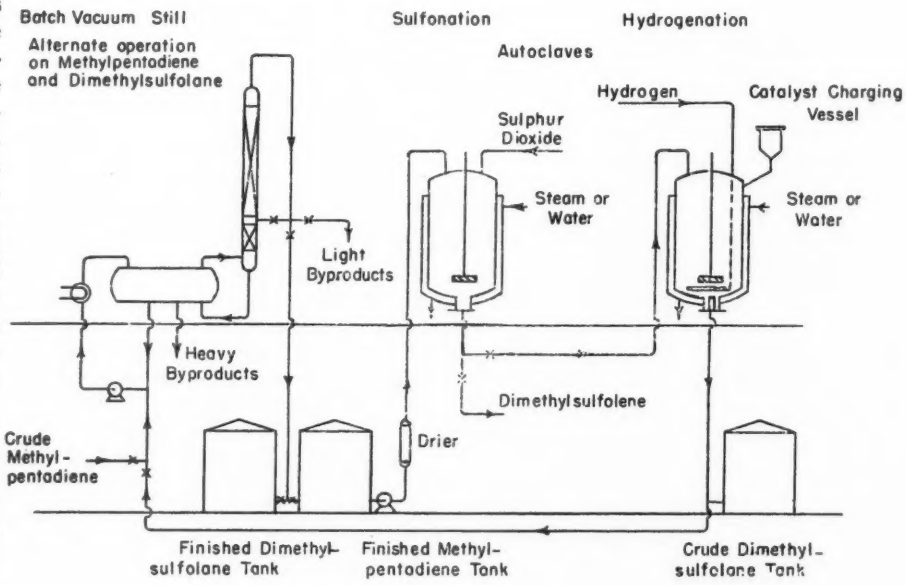
2,4 dimethylsulfolane is made by an analogous method from 2-methyl-1,3-pentadiene and sulfur dioxide.

The sulfolanes are effective as selective solvents for both liquid-vapor and liquid-liquid extraction processes for separating mixtures of components having different degrees of saturation or different degrees of polarity. Thus they can be used to effect the separation of aromatics from paraffins, naphthenes, and olefins; to desulfurize petroleum fractions; and to refine vegetable oils.

Compared with many of the now commercially employed solvents such as liquid sulfur dioxide, furfural, phenol, aniline, nitrobenze, etc., the sulfolanes not only are highly selective for many compounds but also have the advantage of low corrosivity and chemical inertness. For example, liquid sulfur dioxide, phenol,

(*Continued on page 214*)

Flow sheet for the production of dimethylsulfolane from methylpentadiene.



WHAT DO YOU SEE IN THE FUTURE?

SEVENTY-FIVE YEARS AGO half of the people of the United States were farmers. Life was simple in those days.

Every farmer knew just how much he had to raise on his land in order to support his family.

Every blacksmith knew how many horses he had to shoe in order to buy his wife a new dress.

Every farm-hand and blacksmith's helper knew how his wages depended upon his usefulness to the man who shared his income with him.

Life seems more complicated today.

Just about now the world appears to be in pretty much of a mess. Some of us are lost completely in the wilderness of theories and "isms" that surround us and have given up trying to find our own way. Many of us are following the leadership of guides who are taking us in many, widely opposite directions without our noticing this fact. We are behaving like lost hunters who refuse to trust their own compasses.

And yet, life is as simple as it always has been to those who follow the only guide that can take them to their desired goal—their own "horse-sense," their own conscience.

All the theories and isms cannot alter the fact that life depends upon our ability to earn a living. All the theories and isms cannot change the fact that our American way has produced the greatest nation on earth, enjoying the world's highest standards of living.

All the theorists and neoists cannot change these fundamentals:—

Business is the exchange of money for goods and services. Our earning power depends upon our ability to supply these goods or services.

But our earning power also depends upon our neighbors. We can prosper only as our community prospers—as our country prospers—and as the company prospers with which we are connected.

Learning these simple fundamentals is, in itself, a great achievement. It will solve most of our problems. Too many people go through life beating their heads out against them. Too many people fail to realize that these simple fundamentals are the basis of all sound business—that they are the key to every man's welfare.

Let those of us cling to these fundamentals who want our children to inherit a country that continues to offer freedom and equal opportunity for all.

JOHN A. ROEBLING'S SONS COMPANY
TRENTON 2, NEW JERSEY

Manufacturers of Wire Rope and Strand • Fittings • Slings • Aircord, Aircord Terminals and Air Controls • Suspension Bridges and Cables • Aerial Wire Rope Systems Electrical Wire and Cable • Hard, Annealed or Tempered High and Low Carbon Fine and Specialty Wire, Flat Wire, Cold Rolled Strip and Cold Rolled Spring Steel Ski Lifts • Screen, Hardware and Industrial Wire Cloth • Lawn Mowers

WORLD LEADERSHIP
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It has been achieved by Norton Company by seventy years of scientific research.
Norton made grinding wheels 'way back in 1877 . . . has since contributed countless outstanding developments to the abrasive industry . . . and in 1946 introduced 32 ALUNDUM abrasive —the most sensational development since the first manufactured aluminum oxide abrasive (trade-marked ALUNDUM) in 1901. This newest member of the Norton family has given to the metalworking world an abrasive with each super-cutting grain a single crystal, individually produced in the electric furnace.
The Norton plant at Worcester, Mass. is the world's largest for the manufacture of abrasive products. And there are other Norton plants in Bauxite, Arkansas; Hamilton and Chippawa, Ontario; Welwyn Garden City, England; La Courneuve, France; Wesseling, Germany; Corsico, Italy; New South Wales, Australia.
In Troy, N. Y., Norton Behr-Manning Division; Littleton, N. H., Norton-Pike Division.
NORTON
ABRASIVES — GRINDING WHEELS — GRINDING AND LAPPING MACHINES
REFRACTORIES — POROUS MEDIUMS — NON-SLIP FLOORS — NORBIDE PRODUCTS
LABELING MACHINES (BEHR-MANNING DIVISION COATED ABRASIVES AND SHARPENING STONES)

MOLECULES OF LIFE

(*Continued from page 208*)

small molecules, but we dare not attempt an hypothesis as to the mechanism of this synthesis.

An interesting relationship with the androgens and other products is very striking when compared to civetone, a glandular secretion of the civet, and to musk, a similar secretion. Civetone (XXVII) when written in steroid fashion (XXVIIa) resembles the androgens, and it has been found that these ketones do possess androgen activity. A musk-like material isolated from swine testes was found by synthesis to be an epimeric mixture of Δ^{16}-androstene-3-ol. The α epimer was found to possess a very strong musk odor. A theory has been put forth that this might be one method of masculine attraction (in animals only).

CHEMICALS FROM PETROLEUM

(*Continued from page 212*)

aniline, and others react with diolefins and sulfur dioxide may react with mono-olefins. Sulfur dioxide is corrosive. Nitrobenzene reacts with sulfur compounds. Furfural polymerizes and decomposes in the presence of traces of acid or base. In contrast, the sulfolanes have been found to be unreactive in all the aforementioned cases. In addition they can be removed easily from many mixtures by a simple water wash.

Conclusion

Clearly petroleum offers the organic chemical industry a wealth of new raw materials for organic synthesis. The potential supply of pure hydrocarbons is enormous. Techniques for their separation are already in commercial use but their development is far from complete. To achieve the commercial production of the new chemicals described, since they are actually only by-products of petroleum, production of enormous quantities of petroleum is necessary. The bulk of such large production is generally consumed by the gasoline market and the consumer of these chemicals thus gets a "free ride," thanks to the gasoline market, and does not have to carry all operational costs.

Note: Pictures credited to American Institute of Chemical Engineers were published in the Transactions of the Institute as follows:

Trans. A.I.Ch.E. 37, 157–207 (1941)
Trans. A.I.Ch.E. 41, 631–644 (1945).

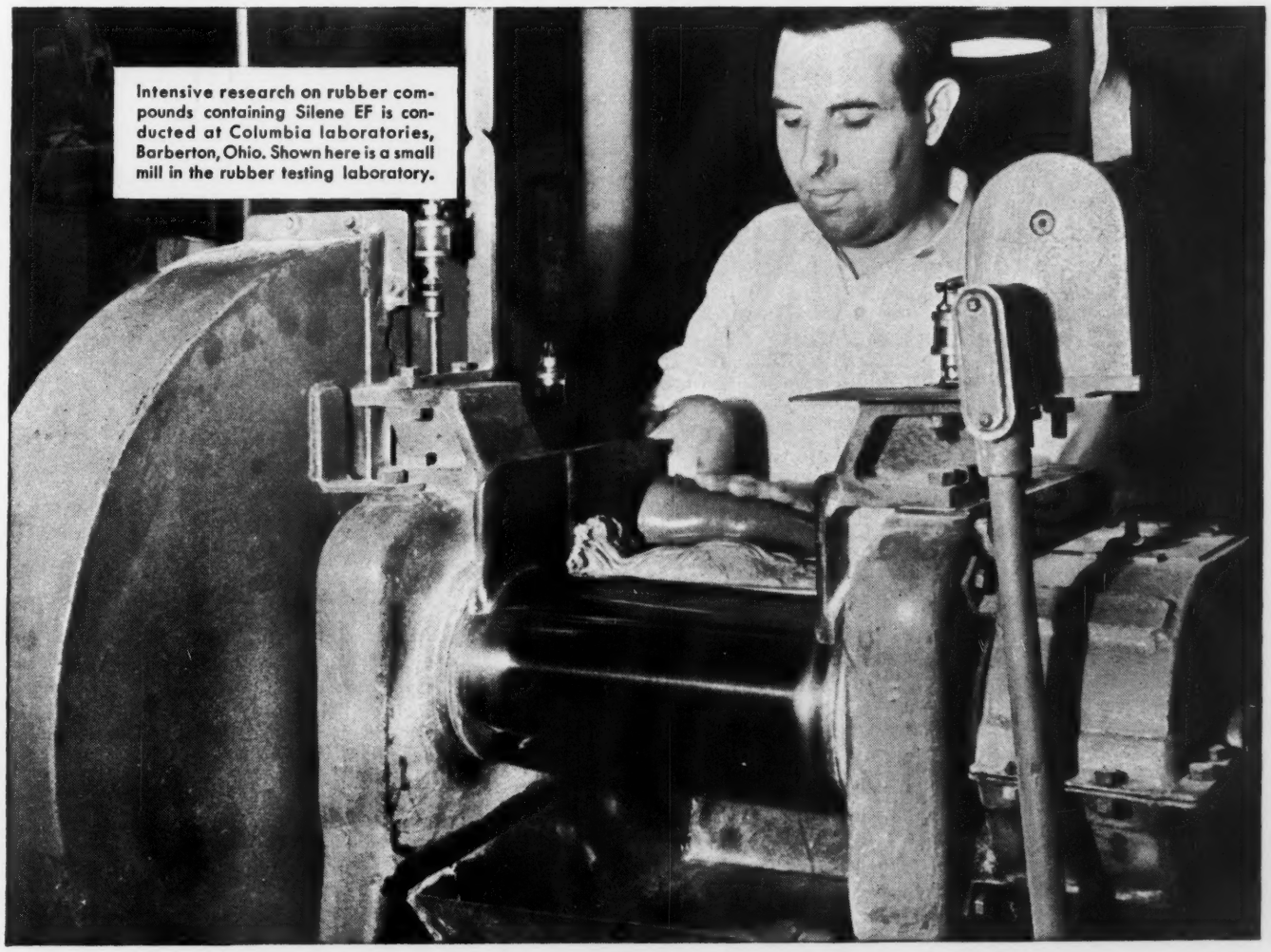
Industry Relies on COLUMBIA *for Essential Chemicals*

Widely used in the manufacture of varied rubber products as the closest approach to a "white carbon black," Silene EF is a white, extremely finely divided precipitated hydrated calcium silicate. An exclusive Columbia pigment, it confers high modulus, hardness, tear resistance and good tensile strength up to high loadings in both natural and synthetic rubbers. Its value is particularly evident in the manufacture of inner tubes and colored abrasion goods. The characteristics of Silene EF also indicate excellent potentials for plastic products, protective coatings, cosmetics, dentifrices, ceramics, and as a base for printing inks and color lakes.

APPROXIMATE ANALYSIS:			
C_2O	19.0	pH in water suspension	10.1
SiO_2	67.0	Specific Gravity	2.10
Loss on Ignition	14.0	Bulk Density	15 to 16 lb. per cu. ft.
		Refractive Index	1.475

SODA ASH
CAUSTIC SODA
LIQUID CHLORINE
CALCIUM CHLORIDE
SODIUM BICARBONATE
MODIFIED SODAS
CAUSTIC ASH
*PHOSFLAKE
(bottle washer)
SODA BRIQUETTES
(iron desulphurizer)
***SILENE EF**
(hydrated calcium silicate)
*CALCENE T
(precipitated calcium carbonate)
*PITTCHLOR
(calcium hypochlorite)

*Trade Marks Reg. U.S. Pat. Off.



Intensive research on rubber compounds containing Silene EF is conducted at Columbia laboratories, Barberton, Ohio. Shown here is a small mill in the rubber testing laboratory.

COLUMBIA CHEMICALS

PITTSBURGH PLATE GLASS COMPANY • COLUMBIA CHEMICAL DIVISION

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• All wires and cables insulated by Okonite's strip process are pressure vulcanized in a continuous metal mold. The Okonite Company, Passaic, N. J.

look for the single ridge

OKONITE SINCE 1878

insulated wires and cables for every electrical use

VACUUM ENGINEERING

(*Continued from page 195*)

and compresses it a definite amount by means of a column of mercury or oil. The column can be calibrated from .001 to 10000 microns. From 1–1000 microns, a Thermocouple gauge which utilizes the principle of the cooling effect of air pressure on a hot wire, may be put into use. In the very low pressure ranges, from .0001 micron to 1 micron, the pressure may be indicated continuously as a function of the gas ionized within an electronic tube.

High vacuum is a powerful tool for procesess previously not practicable; it allows dehydration of blood plasma so that it may be shipped overseas and it may be stored without deterioration. Specially high vacuums (on the order of .0001 microns) are needed for certain types of electronic tubes. High vacuum allows the processor to concentrate and isolate vitamins in pure form. Metals which previously gave trouble on high vacuum jobs because they contained adsorbed gases are now degassed by melting under high vacuum. Certain substances are sintered under vacuum to obtain the required degree of degassing and density. Recently, National Research developed a process of metallizing plastic sheets. These sheets, treated with volatilized aluminum, will probably find use in the places where heavy metal reflectors were previously used.

High vacuum is a tool of the future and of industry. It will be interesting to see what new things will appear because of this as industry gets more and more used to the idea of commercial high vacuum — as they get to use more and more the techniques and "know-how" of vacuum engineering.

"... AND THE LESSER LIGHT"

(*Continued from page 193*)

monthly journey around the Earth. These vary from the New Moon, when it is invisible because of its conjunction, or position directly between the Earth and the Sun, through various crescent stages (see figure) until it is in opposition, as a Full Moon, with the Earth in between the Moon and the Sun. When the Moon is in conjunction, it rises with the Sun, following it across the heavens, and apparently rising in the West at twilight. This continues until it reaches opposition, at which time it reverses the process, rising in the East at sunset, and traveling away from the Sun.

The orbit of the Moon is inclined at a six degree angle from the plane of the ecliptic, or the plane of the Earth's orbit about the Sun. This enables the Full Moon to escape, most of the time, from the conic shadow cast by the Sun on the further side of the Earth, and to reflect a full hemisphere of light. The Moon revolves about its axis only once as it goes around the Earth, so that it always presents the same face to the Earth. No one has ever seen the other side of the Moon, about 41 per cent of its surface, since the axial inclination of the Moon brings nine per cent of the other half into view; but it is safe to infer that it is similar to the visible side.

The surface of the Moon is almost completely pock-marked by crater like structures and vast mountain ranges. These craters, probably volcanic in origin, are on average 15,000 feet deep, and 50 miles wide. The largest of the mountain ranges are the Appennines, stretching 460 miles, some of whose peaks are 20,000 feet high. In between the mountains are vast deserts, called Mares, since they were once thought to be bodies of water.

Although the precise nature of the surface of the Moon is not known, there is much evidence pointing toward volcanic ash. Comparison of the light reflected from the Moon with that reflected from various Earth substances shows a close correlation between the Moon's surface and certain types of lava. There is also another clue. A measurement of the temperature of the surface during an eclipse of the Moon by the Earth, made by Petit and Nicholson at Mount Wilson Observatory, showed a drop of 346°, from 194°F. to −152°, as the Earth's shadow crossed the Moon, cutting off the intense sunlight. Only a very few Earth substances have such tremendous insulating powers, volcanic ash being one of them.

The gravitational pull exerted by the Moon is only one-sixth of the Earth's. This is too low to exceed the escape velocities of atmospheric gases which are greatly speeded up by the intense heat of a fourteen day period of sunshine, so that the Moon has no air. It is for this reason that the Moon is completely devoid of life, sound and sky color.

There are still many mysteries attached to the Moon. From the center of many of its craters, for instance, there are huge raylike formations emanating radially outward, whose origin and nature are as yet unknown. Also, the lack of atmospheric friction makes the Moon a perfect target for meteors. Fortunately, the Earth's atmosphere burns up most of the millions of meteors that shower it daily, but the Moon has no such protection. Yet, there is practically no scar on the Moon's surface that is oblique, indicating angular bombardment. Every falling body must hit it at nearly right angles. Finally, there is the mystery of the other side of the Moon, a secret that will be denied to man until he unleash the bonds that tie him to Earth, and see the Moon first hand.

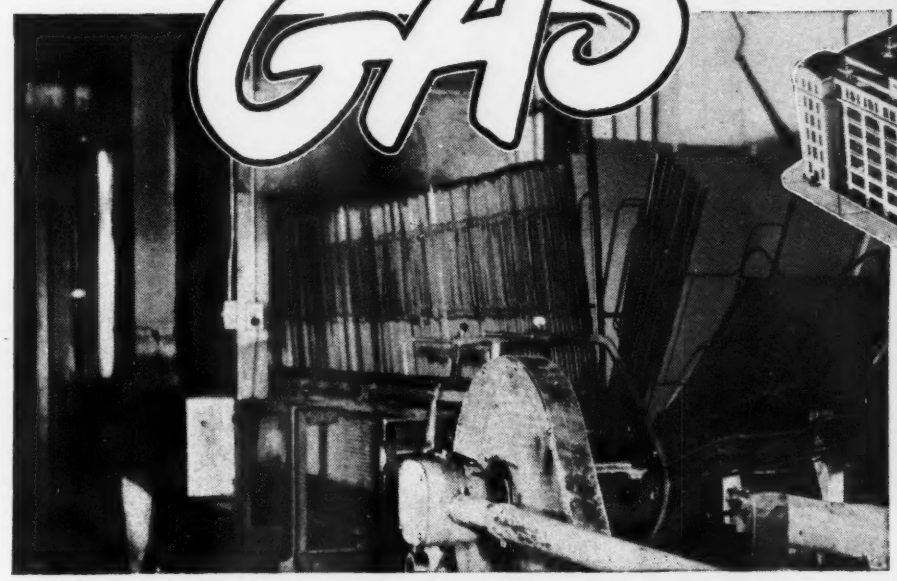
OPERATION: Can Manufacturing

HEATING APPLICATIONS:

- **Joint Preheating**
- **Seam Soldering**
- **Enamel Coating**
- **Lithograph Drying**

FUEL:

GAS



Enamel-coated tinplate emerging from drying oven

American Can Company Plant, Brooklyn, N. Y.

The productive flames of GAS perform essential functions in the manufacture of cans for the foods and beverages packaged by the giant canning industry.

American Can Company's trademark is a familiar sight on the grocery shelf because so many of the best foods are preserved in CANCO cans. As a leading producer, American Can Company has developed streamlined equipment in which heat is a production tool and the heat source is GAS, the invariable choice of design engineers who require fuel flexibility.

For lithograph ovens where uniform temperatures are essential to maintain color tones, in body-making machines where the joint-seal requires pre-heating and solder-melting, in the tunnel ovens for enamel-drying, the remarkably precise controllability of modern GAS equipment is amply evident.

Labor-saving automatic controls, clean and pleasant working conditions, availability and dependability of supply make GAS the preferred fuel for all process heating.

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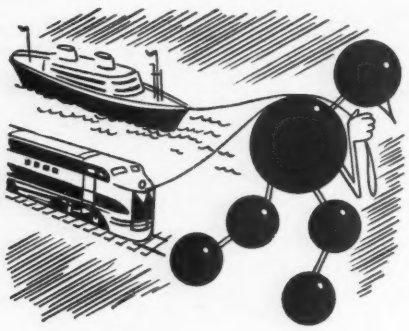
ATOMIC ENERGY

Power for Tomorrow's World

Will nuclear energy drive an automobile indefinitely from a tiny teacup power plant? Will it melt the icecap on Greenland?

These fantastic projects, and others more bizarre, have been publicly advanced as examples of what we may expect from harnessed atomic power. The fact is, such accomplishments are fraught with endless complications and are not possible in the light of anything we know today.

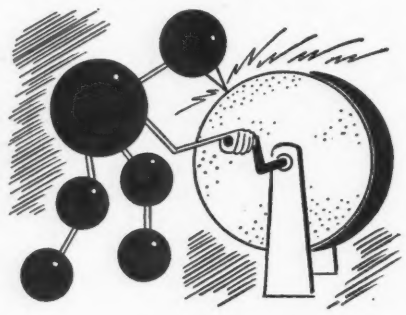


THE ATOM IN INDUSTRY

But one thing is certain. Atomic energy does offer tremendous peacetime potentialities. Sober men of science, not given to heedless predictions, are suggesting applications of nuclear forces to industry that five or six years ago would have startled even readers of "Amazing Stories."

What is General Electric doing about atomic energy? For many years, experiments and development work in nucleonics have been carried on by the General Electric Research Laboratory. It was in 1940 that two G-E scientists, Dr. Kenneth H. Kingdon and Dr. Herbert C. Pollack, successfully isolated the U-235 isotope of uranium from the commercial uranium metal. Other outstanding contributions to atomic progress have been made since then by G-E scientists, and General Electric facilities for nucleonic research have been greatly expanded.

ATOMIC POWER PLANTS?



What sort of immediate developments may be expected from the taming of the atom? G-E Vice President Harry A. Winne, in charge of engineering policy for the Company, had some comments on that when he took part in a radio forum program on the subject, "What Can Atomic Energy Do for the World?" Mr. Winne pointed out that for the foreseeable future atomic energy will not replace, but rather will supplement, other sources of energy. He believes that the first small, experimental atomic power plants may be operating within three or four years. But larger plants introduce new problems. "So in my opinion," says Mr. Winne, "we are not suddenly going to find atomic power plants springing up all over the country."

Exactly what specific achievements nuclear energy will make possible and when it will produce them remains conjectural, of course. However, the key which will continue to unlock the deepest secrets of the atom is *research*. And General Electric's research and development program is already geared to investigate fully this fascinating new field.

G. E.—A GREAT NAME IN CHEMISTRY

One phase of this broad nuclear research program is chemical research being conducted by General Electric. Research in other fields of chemistry is also carried on by General Electric and includes work being done in the fields of silicones, plastics, synthetic resins, and insulating materials. If you want more information on any of these subjects, write General Electric. Address Chemical Department, General Electric Company, Pittsfield, Mass.

A message to students of chemistry and chemical engineering from

DR. WILLIAM D. COOLIDGE

X-ray pioneer and former Director, General Electric Research Laboratory.

To young chemists and engineers, no field holds more challenge or offers more possibilities than that of atomic energy. This new frontier of science is without parallel in the opportunities it provides for significant research.

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